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This edition applies to Version 2, Release 1.0 of Assembler H, Program Product 5668-962 and to any subsequent releases until otherwise indicated in new editions or technical newsletters.

This manual merges assembler information contained in OS/VS-DOS/VSE-VM/370 Assembler Language, GC33-4010, and OS Assembler H Language, GC26-3771.

Changes are periodically made to the information herein; before using this publication in connection with the operation of IBM systems, consult the latest IBM System/370 and 4300 Processors Bibliography, GC20-0001, for the editions that are applicable and current.

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PREFACE

This is a reference manual for the Assembler H Version 2, Release 1, Modification 0, Program Product 5668-962 (hereafter referred to as the Assembler H program or, simply, assembler). It will enable you to answer specific questions about language functions and specifications. In many cases, it also provides information about the purpose of the instruction you refer to, as well as examples of its use.

This manual merges assembler information contained in OS/VS-DOS/VSE-VM/370 Assembler Language, GC33-4010, and OS Assembler H Language, GC26-3771, with the following major differences:

- Only information relevant to Assembler H has been included in this manual. DOS/VSE, OS/MFT, and OS/MVT information has been removed because it is valid only for assemblers other than Assembler H.
- New features provided by Assembler H Version 2, Release 1.0, have been integrated (see the Summary of Amendments for details).
- Programs may be assembled with Assembler H Version 2, Release 1.0, under MVS/Extended Architecture (MVS/XA).
- Information available in manuals listed below under "Related Publications" is not included in this publication; references are made to the appropriate manuals.

NEW FEATURES

New features provided by the Assembler H Version 2 Program Product are:

- A program using System/370 Extended Architecture (S/370-XA) machine instructions may be assembled with Assembler H under MVS/Extended Architecture (MVS/XA), OS/VS2 MVS Release 3.8, OS/VS1 Release 7, MVS/SP V1, VM/XA Migration Aid, or VM/System Product (VM/SP). Programs using the Extended Architecture instruction set can be assembled on any system supported by the above operating systems; however, programs containing Extended Architecture instructions can only be executed on an Extended Architecture mode processor under MVS/XA or with MVS/XA operating as a guest operating system under VM/XA Migration Aid.
- An AMODE attribute allows specification of the entry point of the addressing mode (24-bit, 31-bit, or any [not sensitive to addressing mode] addresses) to be associated with a control section.
- An RMODE attribute allows specification of the residence mode (in the 24-bit addressable range or anywhere) to be associated with a control section.
- New channel command word instructions: CCW1 (format 1) allows 31-bit data addresses; CCW0 (format 0) allows 24-bit data addresses.
- New machine instructions for the IBM 308x models operating in System/370 Extended Architecture mode; in addition, the System/370 set of machine instructions has been expanded. A changed installation option allows users to specify whether the System/370, Extended Architecture, or Universal (all inclusive) instruction set will be used for assemblies.

- Three new instruction types are included for the Extended Architecture object code: E, RRE, and SSE.
- An underscore character is allowed in ordinary symbols.
- Operation is now supported in the CMS (Conversational Monitor System) environment of VM/SP and VM/XA Migration Aid.

WHOM THIS MANUAL IS FOR

This manual is for application programmers coding in the Assembler H language. It is not intended to be used for tutorial purposes; it is for reference only. If you are interested in learning more about assemblers, most libraries have tutorial books on the subject.

MAJOR TOPICS

This manual is divided into three parts.

"Part 1. Assembler Language" contains the following major topics:

"Chapter 1. Introduction to Assembler Language" describes what the assembler does, tells about the language and program, gives the relationship of the assembler to the operating system, and supplies some coding aids.

"Chapter 2. General Information" describes the coding rules for and the structure of the assembler language. It also discusses terms and expressions.

"Chapter 3. Addressing, Program Sectioning, and Linking" talks about how to handle addressing, control and dummy sections, and symbolic linking.

"Chapter 4. Machine Instruction Statements" describes the machine instruction types and their formats.

"Chapter 5. Assembler Instruction Statements" describes the assembler instructions.

"Part 2. Macro Language" contains the following major topics:

"Chapter 6. Introduction to Macro Language" briefly describes the macro instruction statement, definition, library, and so on.

"Chapter 7. How to Prepare Macro Definitions" tells about the components of a macro definition.

"Chapter 8. How to Write Macro Instructions" tells about the format of operands, sublists, and levels of macro instructions.

"Chapter 9. How to Write Conditional Assembly Instructions" describes the SET and sequence symbols, and attributes of assembly instructions.

"Part 3. Appendixes" contains the following appendixes:

"Appendix A. Machine Instruction Format" shows the basic machine formats in relation to the format of the assembler operand field and applicable instructions.

"Appendix B. Assembler Instructions and Statements" lists the related operation, name, and operand entries.

"Appendix C. Summary of Constants" lists the constant types and gives related information concerning each.

"Appendix D. Macro Language Summary" summarizes some of the information contained in Part II.

HOW TO USE THIS MANUAL

Because this is a reference manual, you should use the index or the table of contents to find the subject in which you are interested.

Complete specifications are given for each instruction or feature of the assembler language, except for the machine instructions, which are documented in IBM System/370 Principles of Operation, GA22-7000, and IBM 4300 Processors Principles of Operation, GA22-7070.

ASSEMBLER H PUBLICATIONS

Other publications in the Assembler H library are:

Assembler H Version 2: General Information, GC26-4035, contains a brief description of Assembler H and compares Version 2, Release 1, features with those of Version 1, Release 5, and also compares Assembler H features with those of the VS Assembler.

Assembler H Version 2: Installation, SC26-4030, which contains information necessary for installation of the assembler program.

Assembler H Version 2 Application Programming: Guide, SC26-4036, tells how to use Assembler H, provides an explanation of each of the diagnostic and abnormal termination messages issued by Assembler H, and suggests how you should respond in each case.

Assembler H Version 2: Logic, LY26-3908, describes the design logic and functional characteristics of Assembler H.

Assembler Coding Form, GX28-6509, is a form for coding the program in the proper columns.

RELATED PUBLICATIONS

The following publications provide definitive information about machine instructions:

IBM System/370 Principles of Operation, GA22-7000

IBM 4300 Processors Principles of Operation, GA22-7070

For quick reference, see:

IBM System/370 Reference Summary, GX20-1850

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Chapter 1 describes what the assembler does, tells about the language and program, gives the relationship of the assembler to the operating system, and supplies some coding aids.

Chapter 2 describes the coding rules for and the structure of the assembler language. It also discusses terms and expressions.

Chapter 3 talks about how to handle addressing, control and dummy sections, and symbolic linking.

Chapter 4 describes the machine instruction types and their formats.

Chapter 5 describes the assembler instructions.

In addition, three appendixes relate to this part of the publication. See Part 3.

Appendix A shows the basic machine formats in relation to the format of the assembler operand field and applicable instructions.

Appendix B lists the related operation, name, and operand entries.

Appendix C lists the constant types and gives related information concerning each.

CHAPTER 1. INTRODUCTION TO ASSEMBLER LANGUAGE

A computer can understand and interpret only machine language. Machine language is in binary form and, thus, very difficult to write. The assembler language is a symbolic programming language that you can use to code instructions instead of coding in machine language.

Because the assembler language allows you to use meaningful symbols made up of alphabetic and numeric characters instead of just the binary digits 0 and 1 used in machine language, you can make your coding easier to read, understand, and change. The assembler must translate the symbolic assembler language into machine language before the computer can execute your program, as explained in the following paragraph.

Your program, written in the assembler language, becomes the source module that is input to the assembler. It can be punched into a deck of cards, or entered through a terminal. The assembler processes your source module and produces an object module in machine language (called object code). The object module can be used as input to be processed by another processing program, called the linkage editor. The linkage editor produces a load module that can be loaded later into the main storage of the computer. Once your program is loaded, it can then be executed. Your source module and the object code produced are printed, along with other information, on a program listing.

LANGUAGE COMPATIBILITY

The language used by Assembler H Version 2, Release 1.0, has functional extensions to the language supported by VS Assembler and OS Assembler H Version 1, Release 5.0. Programs written for VS Assembler and OS Assembler H Version 1, Release 5.0, that were successfully assembled with no warning or diagnostic messages, will be assembled correctly by Assembler H Version 2, Release 1.0.

ASSEMBLER LANGUAGE

The assembler language is the symbolic programming language that lies closest to the machine language in form and content. You will, therefore, find the assembler language useful when

- you need to control your program closely, down to the byte and even the bit level, or
- you must write subroutines for functions that are not provided by other symbolic programming languages, such as COBOL, FORTRAN, or PL/I.

The assembler language is made up of statements that represent instructions or comments. The instruction statements are the working part of the language and are divided into the following three groups:

1. Machine instructions
2. Assembler instructions
3. Macro instructions

Machine Instructions

A machine instruction is the symbolic representation of a machine language instruction of the IBM System/370 architecture

instruction set, or of the IBM System/370 extended architecture instruction set. It is called a machine instruction because the assembler translates it into the machine language code the computer can execute. Machine instructions are described in "Chapter 4. Machine Instruction Statements."

Assembler Instructions

An assembler instruction is a request to the assembler program to perform certain operations during the assembly of a source module; for example, defining data constants, defining the end of the source module, and reserving storage areas. Except for the instructions that define constants, the assembler does not translate assembler instructions into object code. The assembler instructions are described in "Chapter 3. Addressing, Program Sectioning, and Linking," "Chapter 5. Assembler Instruction Statements," and"Chapter 9. How to Write Conditional Assembly Instructions."

Macro Instructions

A macro instruction is a request to the assembler program to process a predefined sequence of code called a macro definition. From this definition, the assembler generates machine and assembler instructions, which it then processes as if they were part of the original input in the source module.

IBM supplies macro definitions for input/output, data management, and supervisor operations that you can call for processing by coding the required macro instruction. (These IBM-supplied macro instructions are described in the appropriate Macro Instructions manual.)

You can also prepare your own macro definitions, and call them, by coding the corresponding macro instructions. Rather than code this entire sequence each time it is needed, you can create a macro instruction to represent the sequence and then, each time the sequence is needed, simply code the macro instruction statemant. During assembly, the sequence of instructions represented by the macro instruction is inserted into the object program.

A complete description of the macro facility, including the macro definition, the macro instruction, and the conditional assembly language, is given in "Part 2. Macro Language."

ASSEMBLER PROGRAM

The assembler program, also referred to as the assembler, processes the machine, assembler, and macro instructions you have coded (source statements) in the assembler language, and produces an object module in machine language.

Basic Functions

Processing involves the translation of source statements into machine language, assignment of storage locations to instructions and other elements of the program, and performance of auxiliary assembler functions you have designated. The output of the assembler program is the object program, a machine language translation of the source program. The assembler furnishes a printed listing of the source statements and object program statements and additional information, such as error indications, that are useful in analyzing the program. The object program is in the format required by the linkage editor.

Processing Sequence

The assembler processes the machine and assembler language instructions at different times during its processing sequence. You should be aware of the assembler's processing sequence in order to code your program correctly.

The assembler processes most instructions on two occasions: First at preassembly time and, later, at assembly time. However, it does some processing—for example, macro processing—only at preassembly time.

The assembler also produces information for other processors. The linkage editor uses such information at link-edit time to combine object modules into load modules. The loader loads your program (combined load modules) into virtual storage at program fetch time. Finally, at execution time, the computer executes the object code produced by the assembler at assembly time.

1. The assembler processes all machine instructions, and translates them into object code at assembly time.

2. Assembler instructions are divided into two main types:

   - Ordinary assembler instructions
   - Conditional assembly instructions and the macro processing instructions (MACRO, MEND, MEXIT, MNOTE, and AREAD)

   The following discusses these two main types of assembler instructions.

   a. The assembler processes ordinary assembler instructions at assembly time.

      - The assembler evaluates absolute and relocatable expressions at assembly time; they are sometimes called assembly-time expressions.
      - Some instructions produce output for processing after assembly time (DC, DS, CCW, CCW0, CCW1, ENTRY, EXTRN, WXTRN, PUNCH, and REPRO).

   b. The assembler processes conditional assembly instructions and macro processing instructions at preassembly time.

      - The assembler evaluates the conditional assembly expressions—arithmetic, logical, and character—at preassembly time.
      - The assembler processes the machine and assembler instructions generated from preassembly processing at assembly time.

3. The assembler processes macro instructions at preassembly time.

   Note: The assembler processes the machine and ordinary assembler instructions generated from a macro definition called by a macro instruction at assembly time.

The assembler prints in a program listing all the information it produces at the various processing times discussed above.

RELATIONSHIP OF ASSEMBLER TO OPERATING SYSTEM

Assembler H operates under MVS/Extended Architecture (XA), OS/VS2 MVS 3.8, OS/VS1 Release 7, MVS/System Product (SP) V1, VM/XA Migration Aid, and VM/SP. These operating systems provide the assembler with services for:

- Assembling a source module
- Running the assembled object module as a program

In writing a source module, you must include instructions that request the desired service functions from the operating system.

OS/VS provides the following services:

1. For assembling the source module:
   a. A control program
   b. Libraries to contain source code and macro definitions
   c. Utilities
2. For preparing for the execution of the assembler program as represented by the object module:
   a. A control program
   b. Storage allocation
   c. Input and output facilities
   d. Linkage editor
   e. A loader

CMS provides the following services:

1. For assembling the source module:
   a. An interactive control program
   b. Files to contain source code and macro definitions
   c. Utilities
2. For preparing for the execution of the assembler program as represented by the object modules:
   a. An interactive control program
   b. Storage allocation
   c. Input and output facilities
   d. CMS loader

CODING AIDS

It can be very difficult to write an assembler language program using only machine instructions. The assembler provides additional functions that make this task easier. They are summarized below.

Symbolic Representation of Program Elements

Symbols greatly reduce programming effort and errors. You can define symbols to represent storage addresses, displacements, constants, registers, and almost any element that makes up the assembler language. These elements include operands, operand subfields, terms, and expressions. Symbols are easier to remember and code than numbers; moreover, they are listed in a symbol cross-reference table, which is printed in the program listings. Thus, you can easily find a symbol when searching for an error in your code.

Variety in Data Representation

You can use decimal, binary, hexadecimal, or character representation of machine language binary values in writing source statements. You select the representation best suited to the purpose. The assembler converts your representations into the binary values required by the machine language.

Controlling Address Assignment

If you code the appropriate assembler instruction, the assembler will compute the displacement from a base address of any symbolic addresses you specify in a machine instruction. It will insert this displacement, along with the base register assigned by the assembler instruction, into the object code of the machine instruction.

At execution time, the object code of address references must be in the base-displacement form. The computer obtains the required address by adding the displacement to the base address contained in the base register.

Relocatability

The assembler produces an object module that can be relocated from an originally assigned storage area to any other suitable virtual storage area without affecting program execution. This is made easier because most addresses are assembled in their base-displacement form.

Sectioning a Program

You can divide a source module into one or more control sections. After assembly, you can include or delete individual control sections from the resulting object module before you load it for execution. Control sections can be loaded separately into storage areas that are not contiguous. This means that a sectioned program may be loaded and executed even though a continuous block of storage large enough to accommodate the entire program may not be available.

Linkage between Source Modules

You can create symbolic linkages between separately assembled source modules. This allows you to refer symbolically from one source module to data defined in another source module. You can also use symbolic addresses to branch between modules.

A discussion of sectioning and linking is contained in "Program Sectioning and Linking" on page 45.

Program Listings

The assembler produces a listing of your source module, including any generated statements, and the object code assembled from the source module. You can partly control the form and content of the listing.

The assembler also prints messages about actual errors and warnings about potential errors in your source module.

CHAPTER 2. CODING AND STRUCTURE

This chapter presents information about assembler language coding conventions and assembler language structure.

ASSEMBLER LANGUAGE CODING CONVENTIONS

The following describes the coding conventions that you must follow in writing assembler language programs. Assembler language statements at one time were commonly written on a coding form before they were punched onto cards; now they are usually entered through terminals. In this case, the columns on the form in Figure 1 correspond to positions on a source statement entered through a terminal.

One line of coding on the form is entered to represent one card. The vertical columns on the form correspond to card columns. Space is provided on the form for program identification and instructions to keypunch operators.

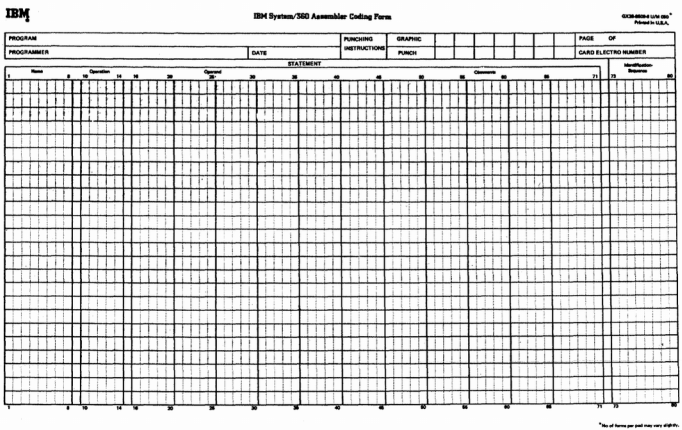


Figure 1. Standard Assembler Coding Form

In the alternative, you can enter source statements through a terminal, using the column format to correspond to positions on your screen or terminal printer.

FIELD BOUNDARIES

Assembler language statements usually occupy one 80-column line on the standard form (for statements occupying more than 80 columns, see "Continuation Lines" on page 10. Note that any printable character punched into any column of a card, or otherwise entered as a position in a source statement, is reproduced in the listing printed by the assembler. All characters are placed in the line by the assembler. Whether they are printed or not depends on the printer. Each line of the coding form is divided into three main fields:

- Statement field
- Continuation indicator field
- Identification-sequence field

Statement Field

The instructions and comments statements must be written in the statement field. The statement field starts in the "begin" column and ends in the "end" column. The continuation indicator field always lies in the column after the "end" column. The identification-sequence field usually lies in the field after the continuation indicator field. Any continuation lines needed must start in the "continue" column and end in the "end" column. The assembler assumes the following standard values for these columns:

- The "begin" column is column 1.
- The "end" column is column 71.
- The "continue" column is column 16.

These standard values can be changed by using the Input Format Control (ICTL) assembler instruction. The ICTL instruction, by changing the standard begin, end, and continue columns can create a field before the begin column; this field can then contain the identification-sequence field. However, all references to the "begin," "end," and "continue" columns in this manual refer to the standard values described above.

Continuation Indicator Field

The continuation indicator field occupies the column after the end column. Therefore, the standard position for this field is column 72. A nonblank character in this column indicates that the current statement is continued on the next line. This column must be blank if a statement is completed on the same line; otherwise, the assembler will treat the statement that follows on the next line as a continuation line of the current statement.

Identification-Sequence Field

The identification-sequence field can contain identification characters or sequence numbers or both. If the ISEQ instruction has been specified to check this field, the assembler will verify whether or not the source statements are in the correct sequence.

The columns checked by the ISEQ function are not restricted to columns 73 through 80, or by the boundaries determined by any ICTL instruction. The columns specified in the ISEQ instruction can be anywhere on the input statements; they can also coincide with columns that are occupied by the instruction field.

CONTINUATION LINES

To continue a statement on another line, the following rules apply:

1. Enter a nonblank character in the continuation indicator field (column 72). This nonblank character must not be part of the statement coding. When more than one continuation line is needed, a nonblank character must be entered in column 72 of each line that is to be continued.

2. Continue the statement on the next line, starting in the continue column (column 16). Columns to the left of the continue column must be blank. Comments may be continued after column 16.

Note that, if an operand is continued after column 16, it is taken to be a comment. Also, if the continuation indicator field is filled in on one line and you try to start a totally new statement after column 16 on the next line, this statement will be taken as a comment belonging to the previous statement.

Unless it is one of the statement types listed below, nine continuation lines are allowed for a single assembler language statement.

ALTERNATIVE STATEMENT FORMAT: The alternative statement format, which allows as many continuation lines as are needed, can be used for the following instructions:

- Prototype statement of a macro definition
- Macro instruction statement
- AGO conditional assembly statement
- AIF conditional assembly statement
- GBLA, GBLB, and GBLC conditional assembly statements
- LCLA, LCLB, and LCLC conditional assembly statements
- SETA, SETB, and SETC conditional assembly statements

Examples of the alternative statement format for each of these instructions are given with the description of the individual instruction.

COMMENTS STATEMENT FORMAT

Comments statements are not assembled as part of the object module, but are only printed in the assembly listing. As many comments statements as needed can be written, subject to the following rules:

- Comments statements require an asterisk in the begin column.

  Note: Internal macro definition comments statements require a period in the begin column, followed by an asterisk.

- Any characters of the IBM System/370 character set, including blanks and special characters, can be used (see "Character Set" on page 13).

- Comments statements must lie in the statement field and not run over into the continuation indicator field; otherwise, the statement following the comments statement will be considered as a continuation line of that comments statement.

- Comments statements must not appear between an instruction statement and its continuation lines.

INSTRUCTION STATEMENT FORMAT

Instruction statements must consist of one to four entries in the statement field. They are:

1. A name entry
2. An operation entry
3. An operand entry
4. A remarks entry

These entries must be separated by one or more blanks, and must be written in the order stated.

Fixed Format

The standard coding form (Figure 1 on page 8) is divided into fields that provide fixed positions for the first three entries, as follows:

- An 8-character name field starting in column 1
- A 5-character operation field starting in column 10
- An operand field that begins in column 16.

Note: With this fixed format, one blank separates each field.

Free Format

It is not necessary to code the name, operation, and operand entries according to the fixed fields on the standard coding form. Instead, these entries can be written in any position, subject to the formatting specifications below.

Formatting Specifications

Whether using fixed or free format, the following general rules apply to the coding of an instruction statement:

1. The entries must be written in the following order: name, operation, operand, and remarks.
2. The entries must be contained in the begin column (1) through the end column (71) of the first line and, if needed, in the continue column (16) through the end column (71) of any continuation lines.
3. The entries must be separated from each other by one or more blanks.
4. If used, a name entry must start in the begin column.
5. The name and operation entries, each followed by at least one blank, must be contained in the first line of an instruction statement.
6. The operation entry must begin at least one column to the right of the begin column.

A description of the name, operation, operand, and remarks entries follows:

NAME ENTRY: The name entry is a symbol created by you to identify an instruction statement. A name entry is usually optional. It must be a valid symbol at assembly time (after substitution for variable symbols, if specified); for an exception, see "TITLE—Identify Assembly Output" on page 140.

The symbol must consist of 63 characters or less, and be entered with the first character appearing in the begin column. The first character must be alphabetic. If the begin column is blank, the assembler program assumes no name has been entered. No blanks may appear in the symbol.

OPERATION ENTRY: The operation entry is the symbolic operation code specifying the machine, assembler, or macro instruction operation desired. The following apply to the operation entry:

- An operation entry is mandatory.
- For machine and assembler instructions, it must be a valid symbol at assembly time (after substitution for variable symbols, if specified). The standard symbolic operation codes are five characters or less (see the appropriate principles of operation manual; or, for assembler operations, see Appendix B, "Assembler Instructions and Statements").

  The standard set of codes can be changed by OPSYN instructions (see "OPSYN—Equate Operation Code" on page 88).
- For macro instructions, it can be any valid symbol that is not identical to any machine or assembler op-code.

OPERAND ENTRIES: Operand entries contain one or more operands that identify and describe data to be acted upon by the instruction, by indicating such information as storage locations, masks, storage area lengths, or types of data. The following rules apply to operands:

- One or more operands are usually required, depending on the instruction.
- Operands must be separated by commas. No blanks are allowed between the operands and the commas that separate them.
- Operands must not contain embedded blanks, because a blank normally indicates the end of the operand entry. However, blanks are allowed if they are included in character strings enclosed in single quotation marks, or in logical expressions.

REMARKS ENTRIES: Remarks are used to describe the current instruction.

- Remarks are optional.
- They can contain any of the 256 valid characters (or punch combinations) of the appropriate character set, including blanks and special characters.
- They can follow any operand entry.

- In statements in which an optional operand entry is omitted but a remarks entry is desired, the absence of the operand entry must be indicated by a comma preceded and followed by one or more blanks, as illustrated below:

Name	Operation	Operand
	END	REMARKS

STATEMENT EXAMPLE: The following example illustrates the use of name, operation, operand, and remarks entries. A compare instruction has been named by the symbol COMP; the operation entry (CR) is the mnemonic operation code for a register-to-register compare operation; and the two operands (5,6) designate the two general registers whose contents are to be compared. The remarks entry reminds readers that "new sum" is being compared to "old" with this instruction.

Name	Operation	Operand
COMP	CR	5,6 NEW SUM TO OLD

CHARACTER SET

Terms, expressions, and character strings used to build source statements are written with the following characters:

Alphabetic Characters A through Z, and $, #, @

Digits 0 through 9

Special Characters + - , = . * ( ) ' / & blank

Underscore Character _

Examples showing the use of the above characters are given in Figure 2 on page 14

The term "alphameric characters" includes both alphabetic characters and digits, but not special characters or the underscore. Normally, you would use strings of alphameric characters to represent data (see "Terms" on page 21), and special characters as:

- Arithmetic operators in expressions
- Data or field delimiters
- Indicators to the assembler for specific handling

These characters are represented by the card-punch combinations and internal bit configurations listed in the IBM System/370 Reference Summary. In addition, any of the 256 punch combinations may be designated anywhere that characters can appear between paired single quotation marks, in comments, and in macro instruction operands.

Characters	Usage	Example	Constituting
Alphameric	In symbols	LABEL NINE#01	Terms
Digits	As decimal self-defining terms	01 9	Terms
Underscore character	In ordinary symbols	SAVE_TOTAL	Terms
Special Characters	As Operators		
+	Addition	NINE+FIVE	Expressions
-	Subtraction	NINE-5	Expressions
*	Multiplication	9*FIVE	Expressions
/	Division	TEN/3	Expressions
+ or -	(Unary)	+NINE -FIVE	Terms
	As Delimiters		
Blanks	Between fields	LABEL AR 3,4	Statement
Comma	Between operands	OPND1,OPND2	Operand field
Apostrophes	Enclosing character strings	C'STRING'	String
Parentheses	Enclosing subfields or subexpressions	MOVE MVC TO(80),FROM (A+B*(C-D))	Statement Expression
	As indicators for		
Ampersand	Variable symbol	&VAR	Term
Period	Sequence symbol	.SEQ	(label)
	Comments statement in Macro definition	.*THIS IS A COMMENT	Statement
	Concatenation	&VAR.A	Term
	Bit-length specification	DC CL.7'AB'	Operand
	Decimal point	DC F'1.7E4'	Operand
Asterisk	Location counter reference	*+72	Expression
	Comments statement	*THIS IS A COMMENT	Statement
Equal sign	Literal reference	L 6,=F'2'	Statement
	Keyword	&KEY=D	Keyword Parameter

Figure 2. Examples Using Character Set

ASSEMBLER LANGUAGE STRUCTURE

This section describes the structure of the assembler language, that is, the various statements that are allowed in the language, and the elements that make up those statements.

A source statement is composed of:

- A name entry (usually optional) that is a symbol
- An operation entry (required) that is a symbolic operation code representing a machine, assembler, or macro instruction
- An operand entry (usually required) that is composed of one or more operands
- A remarks entry (optional)

Notes:

1. The figures in this section show the overall structure of the statements that represent the assembler language instructions, and are not specifications for these instructions. The individual instructions, their purposes, and their specifications are described in other sections of this manual. Model statements, used to generate assembler language statements, are described in "Chapter 7. How to Prepare Macro Definitions."

2. The remarks entry is not processed by the assembler, but only copied into the listings of the program. Therefore, it is not shown except in the overview of the assembler language structure in Figure 3 on page 16.

The machine instruction statements are described in Figure 4 on page 17 , discussed in "Chapter 4. Machine Instruction Statements," and summarized in the appropriate principles of operation manual.

Assembler instruction statements are described in Figure 5 on page 18 , discussed in "Chapter 3. Addressing, Program Sectioning, and Linking" and "Chapter 5. Assembler Instruction Statements," and are summarized in Appendix B, "Assembler Instructions and Statements."

Conditional assembly instruction statements and the macro processing statements (MACRO, MEND, MEXIT, MNOTE, and AREAD) are described in Figure 6 on page 19. The conditional assembly instructions are discussed in "Chapter 9. How to Write Conditional Assembly Instructions," and macro processing instructions, in "Chapter 7. How to Prepare Macro Definitions." Both types are summarized in Appendix B, "Assembler Instructions and Statements."

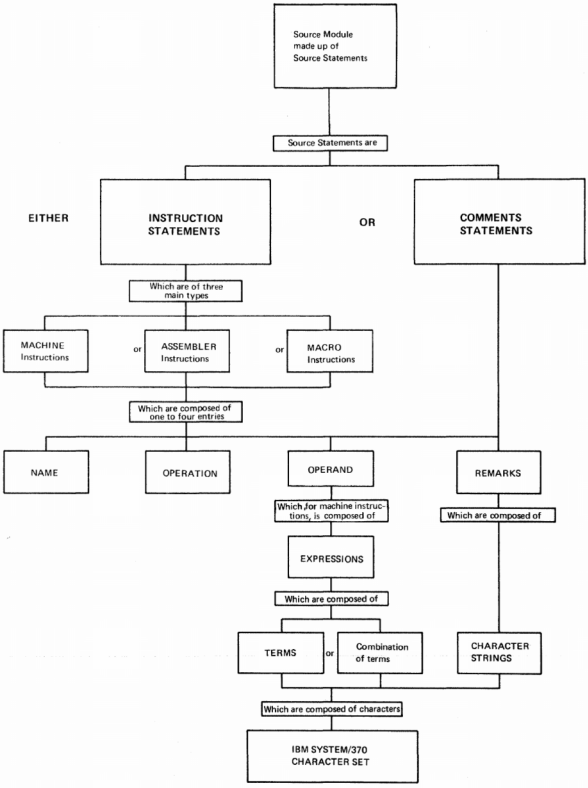


Figure 3. Assembler Language Structure

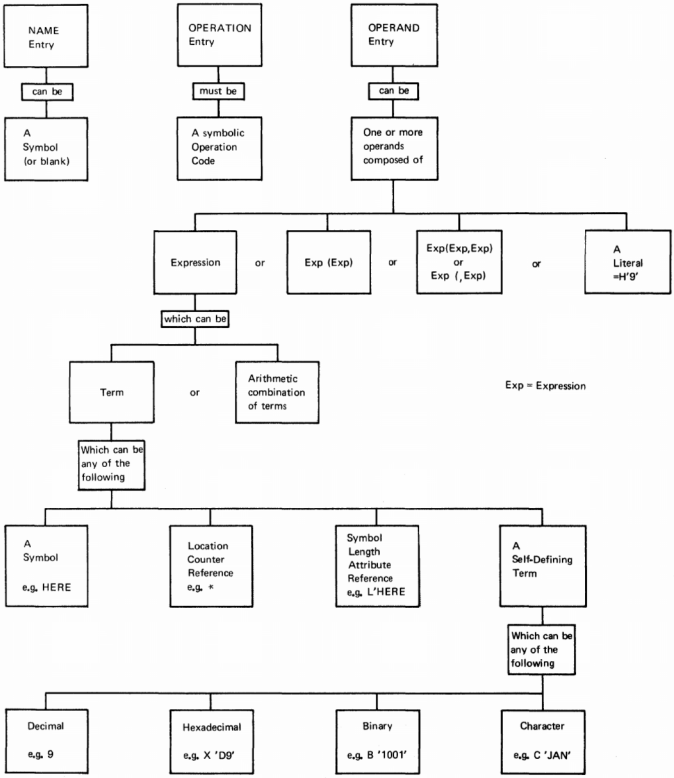
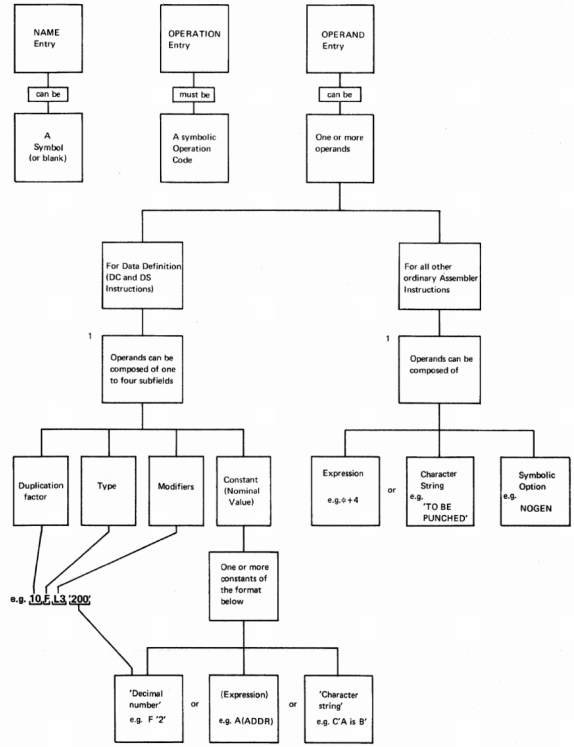


Figure 4. Machine Instructions



[1] Discussed more fully where individual instructions are described

Figure 5. Ordinary Assembler Instruction Statements

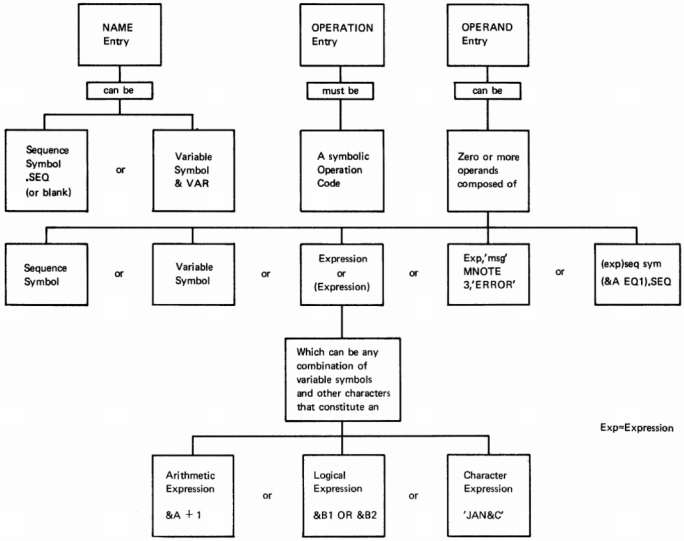


Figure 6. Conditional Assembly Instructions

Macro instruction statements are described in Figure 7 and discussed in "Part 2. Macro Language."

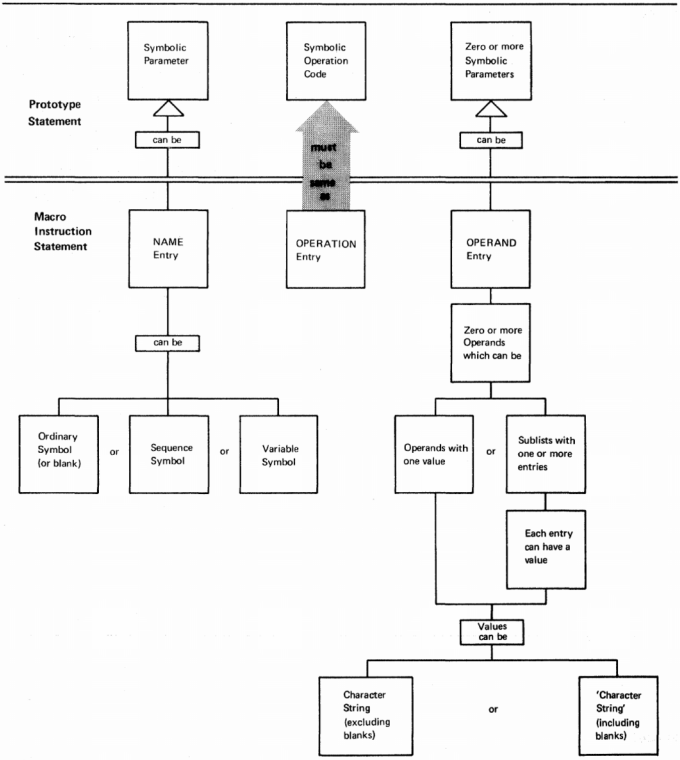


Figure 7. Macro Instructions

TERMS AND EXPRESSIONS

TERMS

A term is the smallest element of the assembler language that represents a distinct and separate value. It can, therefore, be used alone or in combination with other terms to form expressions. Terms are classified as absolute or relocatable, depending on the effect of program relocation upon them. Program relocation is the loading of the object program into storage locations other than those originally assigned by the assembler. Terms have absolute or relocatable values that are assigned by the assembler or that are inherent in the terms themselves.

A term is absolute if its value does not change upon program relocation, and is relocatable if its value changes upon relocation. Figure 8 summarizes the various types of terms. The following text discusses each term and the rules for its use.

Terms	Term Can Be		Value Is	
	Absolute	Relocatable	Assigned by Assembler	Inherent in Term
Symbols	X	X	X	
Location Counter Reference		X	X	
Symbol Length Attribute	X		X	
Other Data Attributes	X		X	
Self-Defining Terms	X			X

Figure 8. Summary of Terms

Symbols

You can use a symbol to represent storage locations or arbitrary values. If you write a symbol in the name field of an instruction, you can then specify this symbol in the operands of other instructions and thus refer to the former instruction symbolically. This symbol represents a relocatable address.

You can also assign an absolute value to a symbol by coding it in the name field of an EQU instruction with an operand whose

value is absolute. This allows you to use this symbol in instruction operands to represent registers, displacements in explicit addresses, immediate data, lengths, and implicit addresses with absolute values. For details of these program elements, see "Operand Entries" on page 72.

The advantages of symbolic over numeric representation are:

1. Symbols are easier to remember and use than numeric values, thus reducing programming errors and increasing programming efficiency.

2. You can use meaningful symbols to describe the program elements they represent; for example, INPUT can name a field that is to contain input data, or INDEX can name a register to be used for indexing.

3. You can change the value of one symbol (through an EQU instruction) more easily than you can change several numeric values in many instructions.

4. Symbols are entered into a cross-reference table that the assembler prints in the program listing. This table helps you to find a symbol in a program listing, because it lists (a) the number of the statement in which the symbol is defined, that is, used as the name entry, and (b) the numbers of all the statements in which the symbol is used in the operands.

SYMBOL TABLE: The assembler maintains an internal table called a symbol table. When the assembler processes your source statements for the first time, it assigns an absolute or relocatable value to every symbol that appears in the name field of an instruction. The assembler enters this value, which normally reflects the setting of the location counter, into the symbol table; it also enters the attributes associated with the data represented by the symbol. The values of the symbol and its attributes are available later when the assembler finds this symbol or attribute reference used as a term in an operand or expression. See "Symbol Length Attribute Reference" and "Self-Defining Terms" in this chapter for more details. The three types of symbols recognized by the assembler are:

- Ordinary symbols
- Variable symbols
- Sequence symbols

Ordinary symbols can be used in the name and operand fields of machine and assembler instruction statements. They must be coded to conform to these rules:

1. The symbol must not consist of more than 63 alphameric characters. The first character must be an alphabetic character (A through Z, $, #, or @). The other characters may be alphabetic characters, digits, or a combination of the two.

2. No special characters may be included in an ordinary symbol.

3. No blanks are allowed in an ordinary symbol.

4. An underscore character is allowed, with the restrictions listed below.

An underscore character must not appear in an external symbol, or in the name field of an OPSYN instruction. The following lists the symbol fields in which the underscore character must not appear:

- In the name field of a CSECT instruction
- In the name field of a DXD instruction
- In the name field of a COM instruction
- In the name field of an OPSYN instruction
- In the operand field of an EXTRN instruction
- In the operand field of a WXTRN instruction
- In the operand field of an ENTRY instruction
- As the nominal value in a V-type or Q-type address constant

In the following sections, the term symbol refers to the ordinary symbol.

The following are valid symbols:

```
ORDSYM#435A         HERE    $OPEN
K4                  #0123   X
B49467LITTLENAIL    @33     SAVE_TOTAL
```

Variable symbols must begin with an & followed by an alphabetic character and, optionally, up to 61 alphameric characters. Variable symbols can only be used in macro processing and conditional assembly instructions. They allow different values to be assigned to one symbol. A complete discussion of variable symbols appears in "Chapter 7. How to Prepare Macro Definitions."

The following are valid symbols:

```
&VARYINGSYMABC      &@ME
&F346944            &A
```

Sequence symbols consist of a period (.) followed by an alphabetic character, and up to 61 additional alphameric characters. Sequence symbols can be used only in macro processing and conditional assembly instructions. They are used to indicate the position of statements within the source program or macro definition. Through their use, you can vary the sequence in which statements are processed by the assembler program. (See the complete discussion in "Chapter 9. How to Write Conditional Assembly Instructions.")

The following are valid symbols:

```
.BLABEL04           .#359
.BRANCHTOMEFIRST    .A
```

SYMBOL DEFINITION: An ordinary symbol is considered defined when it appears as:

- The name entry in a machine or assembler instruction of the assembler language
- One of the operands of an EXTRN or WXTRN instruction

Note: Ordinary symbols that appear in instructions generated from model statements at preassembly time are also considered defined.

In Figure 9, the assembler assigns a value to the ordinary symbol in the name fields as follows:

1. According to the address of the leftmost byte of the storage field that contains one of the following:

   a. (See (1) in Figure 9.) Any machine or assembler instruction (except the EQU or OPSYN instruction)

   b. (See (2) in Figure 9.) A storage area defined by the DS instruction

   c. (See (3) in Figure 9.) Any constant defined by the DC instruction

   d. A channel command word defined by the CCW, CCW0, or CCW1 instruction

   The address value thus assigned is relocatable, because the object code assembled from these items is relocatable; the relocatability of addresses is described "Addresses" on page 74.

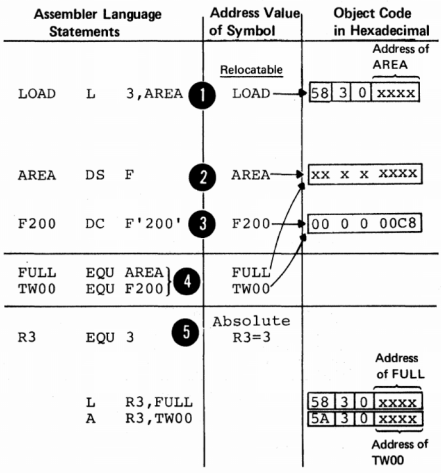


Figure 9. Transition from Assembler Language Statement to Object Code

2. According to the value of the first or only expression specified in the operand of an EQU instruction. This expression can have a relocatable (see (4) in Figure 9) or absolute (see (5) in Figure 9) value, which is then assigned to the ordinary symbol.

   The value of an ordinary symbol must lie in the range -2^{31} through $+2^{31}-1$.

RESTRICTIONS ON SYMBOLS: A symbol must be defined only once in a source module with one or more control sections, with the following exception: The symbol in the name field of a LOCTR instruction can be the same as the name of a previous START, CSECT, DSECT, COM, or LOCTR instruction. It identifies the resumption of the location counter specified by the name field.

Note: The ordinary symbol that appears in the name field of an OPSYN or a TITLE instruction does not constitute a definition of that symbol. It can, therefore, be used in the name field of any other statement in a source module.

PREVIOUSLY DEFINED SYMBOLS: If ordinary symbols appear in operand expressions of ORG and CNOP instructions, in modifier expressions of DC, DS, and DXD statements, in the first operand of EQU statement, or in Q-type constants, they do not need to be previously defined.

Allowing forward reference in the above statement types creates two new kinds of errors that you should guard against.

- Circular definition of symbols, such as:

```
X  EQU  Y
Y  EQU  X
```

- Circular location-counter dependency, as in this example:

```
A  DS  (B-A)C
B  LR  1,2
```

Statement A cannot be resolved because the value of the duplication factor is dependent on the location of B, which is, in turn, dependent upon the length of A.

Literals may contain symbolic expressions in modifiers, but any ordinary symbols used must have been previously defined.

Self-Defining Terms

A self-defining term allows you to specify a value explicitly. With self-defining terms, you can specify decimal, binary, hexadecimal, or character data. These terms have absolute values and can be used as absolute terms in expressions to represent bit configurations, absolute addresses, displacements, length or other modifiers, or duplication factors.

USING SELF-DEFINING TERMS: Self-defining terms represent machine language binary values and are absolute terms; their values do not change upon program relocation. Some examples of self-defining terms and the binary values they represent are given below:

Self-Defining Term	Decimal Value	Binary Value
15	15	1111
241	241	11110001
B'1111'	15	1111
B'11110001'	241	11110001
B'100000001'	257	100000001
X'F'	15	1111
X'F1'	241	11110001
X'101'	257	100000001
C'1'	241	11110001
C'A'	193	11000001
C'AB'	49,602	1100000111000010

The assembler carries the values represented by self-defining terms to 4 bytes or 32 bits; the high-order bit is the sign bit. (A '1' in the sign bit indicates a negative value; a '0' indicates a positive value.)

The use of a self-defining term is distinct from the use of data constants or literals. When a self-defining term is used in a machine instruction statement, its value is assembled into the instruction. When a data constant is referred to or a literal is specified in the operand of an instruction, its address is assembled into the instruction. Self-defining terms are always right-justified; truncation or padding with zeros, if necessary, occurs on the left.

Decimal Self-Defining Term: A decimal self-defining term is simply an unsigned decimal number written as a sequence of decimal digits. High-order zeros may be used (for example, 007). Limitations on the value of the term depend on its use. For example, a decimal term that designates a general register should have a value between 0 and 15; one that represents an address should not exceed the size of storage. In any case, a decimal term may not consist of more than 10 digits, or exceed 2 147 483 647 ($2^{31}-1$). A decimal self-defining term is assembled as its binary equivalent. Some examples of decimal self-defining terms are: 8, 147, 4092, and 00021.

Hexadecimal Self-Defining Term: A hexadecimal self-defining term consists of 1 to 8 hexadecimal digits enclosed in single quotation marks and preceded by the letter X; for example, X'C49'.

Each hexadecimal digit is assembled as its 4-bit binary equivalent. Thus, a hexadecimal term used to represent an 8-bit mask would consist of 2 hexadecimal digits. The maximum value of a hexadecimal term is X'FFFFFFFF'; this allows a range of values from -2 147 483 648 through 2 147 483 647.

The hexadecimal digits and their bit patterns are as follows:

```
0 - 0000    4 - 0100    8 - 1000    C - 1100
1 - 0001    5 - 0101    9 - 1001    D - 1101
2 - 0010    6 - 0110    A - 1010    E - 1110
3 - 0011    7 - 0111    B - 1011    F - 1111
```

Note: When used as an absolute term in an expression, a hexadecimal self-defining term has a negative value if the high-order bit is 1.

Binary Self-Defining Term: A binary self-defining term is written as an unsigned sequence of 1s and 0s enclosed in single quotation marks and preceded by the letter B; for example, B'10001101'. This term would appear in storage as shown, occupying 1 byte. A binary term may have up to 32 bits represented. This allows a range of values from -2 147 483 648 through 2 147 483 647.

Note: When used as an absolute term in an expression, a binary self-defining term has a negative value if the high-order bit is 1.

Binary representation is used primarily in designating bit patterns of masks or in logical operations.

The following illustrates a binary term used as a mask in a Test Under Mask (TM) instruction. The contents of GAMMA are to be tested, bit by bit, against the pattern of bits represented by the binary term.

Name	Operation	Operand
ALPHA	TM	GAMMA,B'10101101'

Character Self-Defining Term: A character self-defining term consists of 1 to 4 characters enclosed in single quotation marks, and must be preceded by the letter C. All letters, decimal digits, and special characters may be used in a character term. In addition, any of the remainder of the 256 punch combinations may be designated in a character self-defining term. Examples of character self-defining terms are:

```
C'/'        C' ' (blank)
C'ABC'      C'13'
```

Because of the use of single quotation marks in the assembler language and ampersands in the macro language as syntactic characters, the following rule must be observed when using these characters in a character term.

For each single quotation mark or ampersand desired in a character self-defining term, two single quotation marks or ampersands must be written. For example, the character value A'& would be written as 'A''&', while a single quotation mark followed by a blank and another single quotation mark would be written as ''' '''.

Each character in the character sequence is assembled as its 8-bit code equivalent. The two single quotation marks or ampersands that must be used to represent a single quotation mark or ampersand within the character sequence are assembled as a single quotation mark or ampersand.

Location Counter Reference

The assembler runs a location counter to assign storage addresses to your program statements. It is the assembler's equivalent of the instruction counter in the computer. You can refer to the current value of the location counter at any place in a source module by specifying an asterisk as a term in an operand.

As the instructions and constants of a source module are being assembled, the location counter has a value that indicates a location in storage. The assembler increments the location counter according to the following:

1. After an instruction or constant has been assembled, the location counter indicates the next available location.

2. Before assembling the current instruction or constant, the assembler checks the boundary alignment required for it and adjusts the location counter, if necessary, to indicate the proper boundary.

3. While the instruction or constant is being assembled, the location counter value does not change. It indicates the location of the current data after boundary alignment and is the value assigned to the symbol, if present, in the name field of the statement.

4. After assembling the instruction or constant, the assembler increments the location counter by the length of the assembled data to indicate the next available location.

These rules are illustrated below:

```
Location                        Source
in Hexadecimal                  Statements

000004          DONE    DC  CL3'ABC'
000007          BEFORE  EQU *
000008          DURING  DC  F'200'
00000C          AFTER   EQU *
000010          NEXT    DS  D
```

You can specify multiple location counters for each control section in a source module; for more details about the location counter setting in control sections, see "Location Counter Setting" on page 47.

The assembler carries an internal location counter value as a 4-byte (32-bit) value, but it only uses the low-order 3 bytes, which are printed in the program listings. However, if you specify addresses greater than $2^{24}-1$, you cause overflow into the high-order byte, and the assembler issues the error message, 'LOCATION COUNTER OVERFLOW'.

You can control the setting of the location counter in a particular control section by using the START or ORG instruction, described in "Chapter 3. Addressing, Program Sectioning, and Linking"and"Chapter 5. Assembler Instruction Statements," respectively. The counter affected by either of these assembler instructions is the counter for the control section in which they appear.

You can refer to the current value of the location counter at any place in a program by using an asterisk as a term in an operand. The asterisk can be specified as a relocatable term according to the following rules:

1. The asterisk can be specified only in the operands of:

   a. Machine instructions

   b. DC and DS instructions

   c. EQU, ORG, and USING instructions

2. It can also be specified in literal constants. See "Literals" on page 32. For example:

```
THERE  L   3,=A(*)
```

The value of the location counter reference (*) is the current value of the location counter of the control section in which

the asterisk (*) is specified as a term. The asterisk has the same value as the address of the first byte of the instruction in which it appears. For example:

```
HERE  B  *+8
```

where the address value of * is the address of HERE.

For the value of the asterisk in address constants with duplication factors, see "Address Constants—A and Y" on page 112.

Symbol Length Attribute Reference

The length attribute of a symbol may be used as a term. Reference to the attribute is made by coding L' followed by the symbol, as in:

```
L'BETA
```

The length attribute of BETA will be substituted for the term. When you specify a symbol length attribute reference, you obtain the length of the instruction or data referred to by a symbol. You can use this reference as a term in instruction operands to:

1. Specify unknown storage area lengths.
2. Cause the assembler to compute length specifications for you.
3. Build expressions to be evaluated by the assembler.

The symbol length attribute reference must be specified according to the following rules:

1. The format must be L' immediately followed by a valid symbol or the location counter reference (*).
2. The symbol must be defined in the same source module in which the symbol length attribute reference is specified.
3. The symbol length attribute reference can be used in the operand of any instruction that requires an absolute term. However, it cannot be used in the form L'* in any instruction or expression that requires a previously defined symbol.

The value of the length attribute is normally the length in bytes of the storage area required by an instruction, constant, or field represented by a symbol. The assembler stores the value of the length attribute in the symbol table along with the address value assigned to the symbol.

When the assembler encounters a symbol length attribute reference, it substitutes the value of the attribute from the symbol table entry for the symbol specified.

The assembler assigns the length attribute values to symbols in the name field of instructions as follows:

- For machine instructions (see (1) in Figure 10 on page 30), it assigns either 2, 4, or 6, depending on the format of the instruction.
- For the DC and DS instructions (see (2) in Figure 10), it assigns either the implicit or explicitly specified length. The length attribute is not affected by a duplication factor.
- For the EQU instruction, it assigns the length attribute value of the leftmost or only term (see (3) in Figure 10) of the first expression in the first operand, unless a specific length attribute is supplied in a second operand.

Note the length attribute values of the following terms in an EQU instruction:

- Self-defining terms (see (4) in Figure 10)
- Location counter reference (see (5) in Figure 10)
- L'* (see (6) in Figure 10)

The length attribute of the location counter reference (L'*—see (7) in Figure 10) is equal to the length attribute of the instruction in which the L'* appears.

Figure 10 illustrates these rules.

Source Module			Value of Symbol Length Attribute (at assembly time)	
MACHA	MVC	TO,FROM	L'MACHA	6
MACHB	L	3,ADCON	L'MACHB	4
MACHC	LR	3,4	L'MACHC	2
TO	DS	CL80	L'TO	80
FROM	DS	CL240	L'FROM	240
ADCON	DC	A(OTHER)	L'ADCON	4
CHAR	DC	C'YUKON'	L'CHAR	5
DUPL	DC	3F'200'	L'DUPL	4
		3		
RELOC1	EQU	TO	L'RELOC1	80
RELOC2	EQU	TO+80	L'RELOC2	80
ABSOL1	EQU	FROM-TO	L'ABSOL1	240
ABSOL2	EQU	ABSOL1	L'ABSOL2	240
SDT1	EQU	102	L'SDT1	1
SDT2	EQU	X'FF'+A-B	L'SDT2	1
SDT3	EQU	C'YUK'	L'SDT3	1
ASTERISK	EQU	*+10	L'ASTERISK	1
LOCTREF	EQU	L'*	L'LOCTREF	1
LENGTH1 DC	A(L'*)		L'*	4
			L'LENGTH1	4
LENGTH2 MVC	TO(L'*),FROM		L'*	6
LENGTH3 MVC	TO(L'TO-20),FROM		L'TO	80

Figure 10. Assignment of Length Attribute Values to Symbols in Name Fields

The following example illustrates use of the L'symbol in moving a character constant into either the high-order or low-order end of a storage field. For ease in following the example, the length attributes of A1 and B2 are mentioned. However, keep in

mind that the L'symbol term makes coding such as this possible in situations where lengths are unknown.

Name	Operation	Operand
A1	DS	CL8
B2	DC	CL2'AB'
HIORD	MVC	A1(L'B2),B2
LOORD	MVC	A1+L'A1-L'B2(L'B2),B2

A1 names a storage field 8 bytes in length and is assigned a length attribute of 8. B2 names a character constant 2 bytes in length and is assigned a length attribute of 2. The statement named HIORD moves the contents of B2 into the leftmost 2 bytes of A1. The term L'B2 in parentheses provides the length specification required by the instruction.

The statement named LOORD moves the contents of B2 into the rightmost 2 bytes of A1. The combination of terms A1+L'A1-L'B2 results in the addition of the length of A1 to the beginning address of A1, and the subtraction of the length of B2 from this value. The result is the address of the seventh byte in field A1. The constant represented by B2 is moved into A1 starting at this address. L'B2 in parentheses provides length specification as in HIORD.

Note: The length attribute of the location counter reference (L'*) is equal to the length attribute of the instruction in which the L'* appears.

Other Attribute References

There are other attributes that describe the characteristics and structure of the data you define in a program; for example, the kind of constant you specify or the number of characters you need to represent a value. These other attributes are the type (T'), length (L'), scaling (S'), integer (I'), count (K'), number (N'), and defined (D') attributes.

Note: You can refer to these attributes only in conditional assembly instructions and expressions; for full details, see "Data Attributes" on page 199.

Terms in Parentheses

Terms in parentheses are reduced to a single value; thus, the terms in parentheses, in effect, become a single term.

Arithmetically combined terms, enclosed in parentheses, may be used in combination with terms outside the parentheses, as follows:

```
14+BETA-(GAMMA-LAMBDA)
```

When the assembler program encounters terms in parentheses in combination with other terms, it first reduces the combination of terms inside the parentheses to a single value which may be absolute or relocatable, depending on the combination of terms. This value is then used in reducing the rest of the combination to another single value.

Terms in parentheses may be included within a set of terms in parentheses:

```
A+B-(C+D-(E+F)+10)
```

The innermost set of terms in parentheses is evaluated first. Six levels of parentheses are allowed; a level of parentheses is a left parenthesis and its corresponding right parenthesis. Parentheses which occur as part of an operand format do not

count in this limit. An arithmetic combination of terms is evaluated as described in the next section.

LITERALS

You can use literals as operands in order to introduce data into your program. However, you cannot use a literal as a term in an expression. The literal represents data rather than a reference to data. This is convenient, because

- The data you enter as numbers for computation, addresses, or messages to be printed is visible in the instruction in which the literal appears.
- You avoid defining constants elsewhere in your source module and then using their symbolic names in machine instruction operands.

The assembler assembles the data specified in a literal into a "literal pool" (described below). It then assembles the address of this literal data in the pool into the object code of the instruction that contains the literal specification. Thus, the assembler saves you a programming step by storing your literal data for you. The assembler also organizes literal pools efficiently, so that the literal data is aligned on the proper boundary alignment and occupies the minimum amount of space.

Literals, Constants, and Self-Defining Terms

Literals, constants, and self-defining terms differ in three important ways:

1. Where you can specify them in machine instructions, that is, whether they represent data or an address of data
2. Whether they have relocatable or absolute values
3. What is assembled into the object code of the machine instruction in which they appear

Figure 11 on page 33 illustrates the first two points.

- A literal represents data (see (1) in Figure 11).
- A constant is represented by its relocatable address (see (2) in Figure 11). Note that a symbol with an absolute value does not represent the address of a constant, but represents immediate data (see (3) in Figure 11) or an absolute address (see (4) in Figure 11).
- A self-defining term represents data and has an absolute value (see (5) in Figure 11).

Compare:

A literal with a relocatable address

```
                 1
        L    3,=F'33'  } same effect
        L    3,F33     }
        .          2
        .
F33     DC   F'33'
```

A Literal with a self-defining term
and a symbol with an absolute value

```
                 1
        MVC  FLAG,=X'00'  }
        MVI  FLAG,X'00'   } same effect
        MVI  FLAG,ZERO    5
        .          3
        .
FLAG    DS   X
ZERO    EQU  X'00'
```

A symbol having an absolute address value
with a self-defining term

```
                 4
        LA   4,LOCORE  } same effect
        LA   4,1000    }
        .          5
        .
LOCORE  EQU  1000
```

Figure 11. Differences between Literals, Constants, and Self-Defining Terms

Figure 12 on page 34 illustrates the third point.

- The address of the literal, rather than the literal data itself, is assembled into the object code (see (1) in Figure 12).
- The address of a constant is assembled into the object code (see (2) in Figure 12). Note that when a symbol with an absolute value (see (3) in Figure 12) represents immediate data, it is the absolute value that is assembled into the object code.
- The absolute value of a self-defining term is assembled into the object code (see (4) in Figure 12).

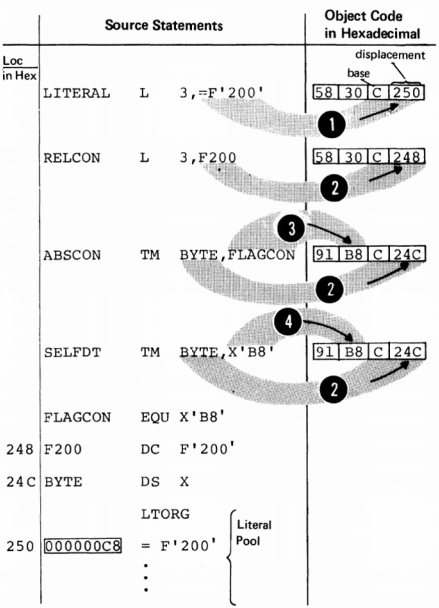


Figure 12. Differences between Literals, Constants, and Self-Defining Terms

General Rules for Literal Usage

A literal is not a term and can be specified only as a complete operand in a machine instruction. In instructions with the RX format, they must not be specified in operands in which an index register is also specified.

Because literals provide "read-only" data, they must not be used:

- In operands that represent the receiving field of an instruction that modifies storage
- In any shift or I/O instruction

The assembler requires a description of the type of literal being specified as well as the literal itself. This descriptive information assists the assembler in assembling the literal correctly. The descriptive portion of the literal must indicate the format of the constant. It can also specify the length of the constant.

A literal must be coded as indicated here:

```
=10XL5'F3'
```

where the subfields are:

```
Duplication factor 10
Type                X
Modifiers          L5
Nominal value    'F3'
```

The method of describing and specifying a constant as a literal is nearly identical to the method of specifying it in the operand of a DC assembler instruction. The major difference is that the literal must start with an equal sign (=), which indicates to the assembler that a literal follows. (Refer to the discussion of the DC assembler instruction operand format in "Chapter 5. Assembler Instruction Statements" for the means of specifying a literal.)

The instruction below shows one use of a literal.

Name	Operation	Operand
GAMMA	L	10,=F'274'

The statement GAMMA is a load instruction using a literal as the second operand. When assembled, the second operand of the instruction will be the address at which the value F'274' is stored.

In general, literals can be used wherever a storage address is permitted as an operand. They cannot, however, be used in any assembler instruction that requires the use of a previously defined symbol. Literals are considered relocatable because the address of the literal, rather than the literal itself, will be assembled in the statement that employs a literal. The assembler generates the literals, collects them, and places them in a specific area of storage, as explained under "Literal Pool." A literal is not to be confused with the immediate data in an SI instruction. Immediate data is assembled into the instruction.

Literal Pool

The literals processed by the assembler are collected and placed in a special area called the literal pool. The location of the literal, rather than the literal itself, is assembled in the statement employing a literal. The positioning of the literal pool can be controlled by you, if desired. Unless otherwise specified, the literal pool is placed at the end of the first control section.

You can also specify that multiple literal pools be created. However, the sequence in which literals are ordered within the pool is controlled by the assembler. Further information on positioning the literal pool(s) is in "LTORG—Begin Literal Pool" on page 135.

EXPRESSIONS

This section discusses the expressions used in coding operand entries for source statements. You can use an expressions to specify:

- An address
- An explicit length
- A modifier
- A duplication factor
- A complete operand

Expressions have absolute and relocatable values. Whether an expression is absolute or relocatable depends on the value of the terms it contains. You can use an absolute or relocatable expression in a machine instruction or any assembler instruction other than a conditional assembly instruction. The assembler evaluates relocatable and absolute expressions at assembly time.

Note: There are three types of expression that you can use only in conditional assembly instructions: arithmetic, logical, and character expressions. They are evaluated at preassembly time. Figure 13 on page 37 defines both absolute and relocatable expressions.

An expression is composed of a single term or an arithmetic combination of terms. The assembler reduces multiterm expressions to single values. Thus, you do not have to compute these values yourself. The following are examples of valid expressions:

```
*                                   BETA*10
AREA1+X'2D'                         B'101'
*+32                                C'ABC'
N-25                                29
FIELD+332                           L'FIELD
FIELD                               LAMBDA+GAMMA
(EXIT-ENTRY+1)+GO                   TEN/TWO
=F'1234'
ALPHA-BETA/(10+AREA*L'FIELD)-100
```

Rules for Coding Expressions

The rules for coding an absolute or relocatable expression are:

1. Both unary (operating on one value) and binary (operating on two values) operators are allowed in expressions.
2. An expression can have one or more unary operators preceding any term in the expression or at the beginning of the expression.
3. An expression must not begin with a binary operator, nor can it contain two binary operators in succession.
4. An expression must not contain two terms in succession.
5. No blanks are allowed between an operator and a term, nor between two successive operators.
6. An expression can contain up to 19 unary and binary operators, and up to 6 levels of parentheses. Note that parentheses that are part of an operand specification do not count toward this limit.
7. A single relocatable term is not allowed in a multiply or divide operation. Note that paired relocatable terms have absolute values and can be multiplied and divided if they are enclosed in parentheses.

8. A literal is not a valid term and is therefore not allowed in an expression.

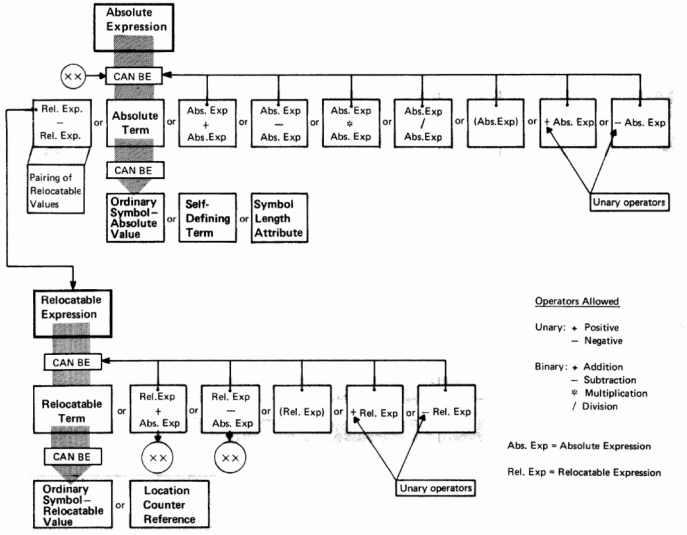


Figure 13. Definitions of Absolute and Relocatable Expressions

Evaluation of Expressions

A single-term expression—for example, 29, BETA, *, L'SYMBOL—takes on the value of the term involved.

The assembler reduces a multiterm expression—for example, BETA+10, ENTRY-EXIT, 25*10+A/B—to a single value, as follows:

1. It evaluates each term.

2. It performs arithmetic operations from left to right. However,

a. It performs unary operations before binary operations.

b. It performs binary operations of multiplication and division before the binary operations of addition and subtraction.

3. In division, it gives an integer result; any fractional portion is dropped. Division by zero gives 0.

4. In parenthesized expressions, the assembler evaluates the innermost expressions first and then considers them as terms in the next outer level of expressions. It continues this process until the outermost expression is evaluated.

5. A term or expression's intermediate value and computed result must lie in the range of -2^{31} through $+2^{31}-1$.

Note: It is assumed that the assembler evaluates paired relocatable terms at each level of expression nesting.

Absolute and Relocatable Expressions

An expression is called absolute if its value is unaffected by program relocation. An expression is called relocatable if its value depends upon program relocation. The two types of expressions, absolute and relocatable, take on these characteristics from the term or terms composing them. A description of the factors that determine whether an expression is absolute or relocatable follows.

ABSOLUTE EXPRESSION: The assembler reduces an absolute expression to a single absolute value if the expression:

1. Is composed of a symbol with an absolute value, a self-defining term, or a symbol length attribute reference, or any arithmetic combination of absolute terms.

2. Contains relocatable terms alone or in combination with absolute terms, and if all these relocatable terms are paired.

PAIRED RELOCATABLE TERMS: An expression can be absolute even though it contains relocatable terms, provided that all the relocatable terms are paired. The pairing of relocatable terms cancels the effect of relocation.

The assembler reduces paired terms to single absolute terms in the intermediate stages of evaluation. The assembler considers relocatable terms as paired under the following conditions:

- The paired terms must be defined in the same control section of a source module (that is, have the same relocatability attribute).

- The paired terms must have opposite signs after all unary operators are resolved. In an expression, the paired terms do not have to be contiguous (that is, other terms can come between the paired terms).

- The value represented by the paired terms is absolute.

The following examples illustrate absolute expressions. A is an absolute term; X and Y are relocatable terms with the same relocatability.

```
A-Y+X
A
A*A
X-Y+A
*-Y[1]
```

[1] A reference to the location counter must be paired with another relocatable term from the same control section; that is, with the same relocatability.

RELOCATABLE EXPRESSION: A relocatable expression is one whose value changes by n if the program in which it appears is relocated n bytes away from its originally assigned area of storage.

A relocatable expression can be a single relocatable term. The assembler reduces a relocatable expression to a single relocatable value if the expression:

1. Is composed of a single relocatable term, or
2. Contains relocatable terms, alone or in combination with absolute terms, and
   a. All the relocatable terms but one are paired. Note that the unpaired term gives the expression a relocatable value; the paired relocatable terms and other absolute terms constitute increments or decrements to the value of the unpaired term.
   b. The relocatability attribute of the whole expression is that of the unpaired term.
   c. The sign preceding the unpaired relocatable term must be positive, after all unary operators have been resolved.

The following examples illustrate relocatable expressions. A is an absolute term, W and X are relocatable terms with the same relocatability attribute, and Y is a relocatable term with a different relocatability attribute.

```
Y-32*A      W-X+*          =F'1234' (literal)
W-X+Y                      A*A+W-W+Y
* (reference to            W-X+W
  location counter)        Y
```

COMPLEX RELOCATABLE EXPRESSIONS: Complex relocatable expressions, unlike relocatable expressions, can contain:

- Two or more unpaired relocatable terms, or
- An unpaired relocatable term preceded by a negative sign.

Complex relocatable expressions can be used only in A-type and Y-type address constants (for more detail, see "A-Type and Y-Type Address Constants" in "Chapter 5. Assembler Instruction Statements").

CHAPTER 3. ADDRESSING, PROGRAM SECTIONING, AND LINKING

ADDRESSING

This part of the chapter describes the techniques and instructions that allow you to use symbolic addresses when referring to data. You can address data that is defined within the same source module, or data that is defined in another source module. Symbolic addresses are more meaningful and easier to use than the corresponding object code addresses required for machine instructions. Also, the assembler can convert the symbolic addresses you specify into their object code form.

ADDRESSING WITHIN SOURCE MODULES: ESTABLISHING ADDRESSABILITY

By establishing the addressability of a control section, you can refer to the symbolic addresses defined in it in the operands of machine instructions. This is much easier than coding the addresses in the base-displacement form required by the System/370. The symbolic addresses you code in the instruction operands are called implicit addresses, and the addresses in the base-displacement form are called explicit addresses.

The assembler will convert these implicit addresses for you into the explicit addresses required for the assembled object code of the machine instruction. However, you must supply the assembler with:

1. A base address from which it can compute displacements to the addresses within a control section
2. A base register to hold this base address

How to Establish Addressability

To establish the addressability of a coding section, you must, when coding:

- Specify a base address from which the assembler can compute displacements.
- Assign a base register to contain this base address.
- Write the instruction that loads the base register with the base address.

During assembly, the implicit addresses you code are converted into their explicit base-displacement form; then, they are assembled into the object code of the machine instructions in which they have been coded.

During execution, the base address is loaded into the base register, and should remain there throughout the execution of your program.

BASE REGISTER INSTRUCTIONS

The USING and DROP assembler instructions enable you to use expressions representing implicit addresses as operands of machine instruction statements, leaving the assignment of base registers and the calculation of displacements to the assembler.

In order to use symbols in the operand field of machine instruction statements, you must (1) indicate to the assembler,

by means of a USING statement, that one or more general registers are available for use as base registers, (2) specify, by means of the USING statement, what value each base register contains, and (3) load each base register with the value you have specified for it.

Having the assembler determine base registers and displacements relieves you of the need to separate each address into a displacement value and a base address value. This feature of the assembler will eliminate a likely source of programming errors, thus reducing the time required to check out programs. You use the USING and DROP instructions described in this chapter to take advantage of this feature. The principal discussion of this feature follows the description of both instructions.

USING—Use Base Address Register

The USING instruction allows you to specify a base address and assign one or more base registers. If you also load the base register with the base address, you have established addressability in a control section.

To use the USING instruction correctly, you should know:

1. Which locations in a control section are made addressable by the USING instruction
2. Where in a source module you can use these established addresses as implicit addresses in instruction operands

The format of the USING instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	USING	BASE,BASEREG1 [,BASEREG2]...

The operand, BASE, specifies a base address, which can be a relocatable or an absolute expression. The value of the expression must lie between -2^{24} and $2^{24}-1$.

The remaining operands specify from 1 to 16 base registers. The operands must be absolute expressions whose values lie in the range 0 through 15.

The assembler assumes that the first base register (BASEREG1) contains the base address BASE at execution time. If present, the subsequent operands, BASEREG2, BASEREG3,..., represent registers that the assembler assumes will contain the address values, BASE+4096, BASE+8192,..., respectively.

For example:

```
  USING  BASE,9,10,11
```

has the logical equivalent of:

```
  USING  BASE,9
  USING  BASE+4096,10
  USING  BASE+8192,11
```

In another example, the following statement

Name	Operation	Operand
	USING	*,12,13

tells the assembler it may assume that the current value of the location counter will be in general register 12 at object time, and that the current value of the location counter, incremented by 4096, will be in general register 13 at object time.

If you change the value in a base register currently being used, and wish the assembler to compute displacement from this value, you must tell the assembler the new value by means of another USING statement. In the following sequence, the assembler first assumes that the value of ALPHA is in register 9. The second statement then causes the assembler to assume that ALPHA+1000 is the value in register 9.

Name	Operation	Operand
	USING	ALPHA,9
	.	
	USING	ALPHA+1000,9

If you must refer to the first 4096 bytes of storage, general register 0 can be used as a base register, subject to the following conditions:

- The value of operand BASE must be either absolute or relocatable zero or simply relocatable.
- Register 0 must be specified as BASEREG1.

The assembler assumes that register 0 contains zero. Therefore, regardless of the value of operand BASE, it calculates displacements as if operand BASE were absolute or relocatable zero. The assembler also assumes that subsequent registers specified in the same USING statement contain 4096, 8192, etc.

Note: If register 0 is used as a base register, the program is not relocatable, despite the fact that operand BASE may be relocatable. The program can be made relocatable by:

- Replacing register 0 in the USING statement
- Loading the new register with a relocatable value
- Reassembling the program

RANGE OF A USING INSTRUCTION: The range of a USING instruction (called the USING range) is the 4096 bytes beginning at the base address specified in the USING instruction. Addresses that lie within the USING range can be converted from their implicit to their explicit form; those outside the USING range cannot be converted.

The USING range does not depend upon the position of the USING instruction in the source module; rather, it depends upon the location of the base address specified in the USING instruction.

Note: The USING range is the range of addresses in a control section that is associated with the base register specified in the USING instruction. If the USING instruction assigns more than one base register, the composite USING range is the sum of the USING ranges that would apply if the base registers were specified in separate USING instructions.

DOMAIN OF A USING INSTRUCTION: The domain of a USING instruction (called the USING domain) begins where the USING instruction appears in a source module and continues to the end of the source module. (Exceptions are discussed later, under "Notes about the USING Domain.") The assembler converts implicit address references into their explicit form:

- If the address reference appears in the domain of a USING instruction, and

- If the addresses referred to lie within the range of the same USING instruction.

The assembler does not convert address references that are outside the USING domain. The USING domain depends on the position of the USING instruction in the source module after conditional assembly, if any, has been performed.

HOW TO USE THE USING INSTRUCTION: You should specify your USING instruction so that:

- All the addresses in each control section lie within a USING range.
- All the references for these addresses lie within the corresponding USING domain.

You should, therefore, place all USING instructions at the beginning of the source module and specify a base address in each USING instruction that lies at the beginning of each control section.

For Executable Control Sections: To establish the addressability of an executable control section defined by a START or CSECT instruction, you specify a base address and assign a base register in the USING instruction. At execution time, the base register is loaded with the correct base address.

If a control section is longer than 4096 bytes, you must assign more than one base register. This allows you to establish the addressability of the entire control section with one USING instruction.

For Reference Control Sections: A dummy section is a reference control section defined by the DSECT instructions. To establish the addressability of a dummy section, you should specify the address of the first byte of the dummy section as the base address so that all its addresses lie within the pertinent USING range. The address you load into the base register must be the address of the storage area being formatted by the dummy section.

Note: The assembler assumes that you are referring to the symbolic addresses of the dummy section, and it computes displacements accordingly. However, at execution time, the assembled addresses refer to the location of real data in the storage area.

NOTES ABOUT THE USING DOMAIN: The domain of a USING instruction continues until the end of a source module, except when:

- A subsequent DROP instruction specifies the same base register or registers assigned by the preceding USING instruction.
- A subsequent USING instruction specifies the same register or registers assigned by the preceding USING instruction.

NOTES ABOUT THE USING RANGE: Two USING ranges coincide when the same base address is specified in two different USING instructions, even though the base registers used are different. When two USING ranges coincide, the assembler uses the higher-numbered register for assembling the addresses within the common USING range. In effect, the first USING domain is terminated after the second USING instruction.

Two USING ranges overlap when the base address of one USING instruction lies within the range of another USING instruction. When two ranges overlap, the assembler computes displacements from the base address that gives the smallest displacement; it uses the corresponding base register when it assembles the addresses within the range overlap. This applies only to implicit addresses that appear after the second USING instruction.

BASE REGISTERS FOR ABSOLUTE ADDRESSES: Absolute addresses used in a source module must also be made addressable. Absolute addresses require a base register other than the base register assigned to relocatable addresses (as described above).

However, the assembler does not need a USING instruction to convert absolute implicit addresses in the range 0 through 4095 to their explicit form. The assembler uses register 0 as a base register. Displacements are computed from the base address 0, because the assembler assumes that a base or index of 0 implies that a zero quantity is to be used in forming the address, regardless of the contents of register 0. The USING domain for this automatic base register assignment is the whole of a source module.

For absolute implicit addresses greater than 4095, a USING instruction must be specified according to the following:

- With a base address representing an absolute expression
- With a base register than has not been assigned by a USING instruction in which a relocatable base address is specified

This base register must be loaded with the base address specified.

DROP—Drop Base Register

You can use the DROP instruction to indicate to the assembler that one or more registers are no longer available as base registers. This allows you:

- To free base registers for other programming purposes
- To ensure that the assembler uses the base register you wish in a particular coding situation; for example, when two USING ranges overlap or coincide

The format of the DROP instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	DROP	BASEREG1[,BASEREG2]... or blank

Up to 16 operands can be specified. They must be absolute expressions whose values represent the general registers 0 through 15. The expressions in the operand indicate general registers previously named in a USING statement that are now unavailable for base addressing. A DROP instruction with a blank operand field causes all currently active base registers assigned by USING instructions to be dropped.

After a DROP instruction, the assembler will not use the registers specified in a DROP instruction as base registers. A register made unavailable as a base register by a DROP instruction can be reassigned as a base register by a subsequent USING instruction.

The following statement, for example, prevents the assembler from using registers 7 and 11:

Name	Operation	Operand
	DROP	7,11

A DROP instruction is not needed:

- If the base address is being changed by a new USING instruction, and the same base register is assigned; however, the new base address must be loaded into the base register.
- At the end of a source module.

RELATIVE ADDRESSING

Relative addressing is the technique of addressing instructions and data areas by designating their location in relation to the location counter or to some symbolic location. This type of addressing is always in bytes—never in bits, words, or instructions. Thus, the expression *+4 specifies an address that is 4 bytes greater than the current value of the location counter. In the sequence of instructions in the following example, the location of the CR machine instruction can be expressed in two ways, ALPHA+2, or BETA-4, because all the mnemonics in the example are for 2-byte instructions in the RR format.

Name	Operation	Operand
ALPHA	LR	3,4
	CR	4,6
	BCR	1,14
BETA	AR	2,3

PROGRAM SECTIONING AND LINKING

This part of the chapter explains how you can subdivide a large program into smaller parts that are easier to understand and maintain. It also explains how you can divide these smaller parts into convenient sections; for example, one section to contain your executable instructions, and another section to contain your data constants and areas.

You should consider two different subdivisions when writing an assembler language program:

1. The source module
2. The control section

You can divide a program into two or more source modules. Each source module is assembled into a separate object module. The object modules can then be combined into load modules to form an executable program.

You can also divide a source module into two or more control sections. Each control section is assembled as part of an object module. By writing the proper link-edit control statements, you can select a complete object module or any individual control section of the object module to be link-edited and later loaded as an executable program.

Size of Program Parts: If a source module becomes so large that its logic is not easily understood, divide it into smaller modules.

Unless you have special programming reasons, you should write each control section so that the resulting object code is not larger than 4096 bytes. This is the largest number of bytes that can be covered by one base register.

Communication Between Program Parts: You must be able to communicate between the parts of your program; that is, be able to refer to data in a different part or be able to branch to another part.

To communicate between two or more source modules, you must symbolically link them together.

To communicate between two or more control sections within a source module, you must establish the addressability of each control properly from one section to another regardless of the relative section.

SOURCE MODULE

A source module is composed of source statements in the assembler language. You can include these statements in the source module in two ways:

1. You write them on a coding form and then enter them as input through a terminal or, using punched cards, through a card reader.

2. You specify one or more COPY instructions among the source statements being entered. When the assembler encounters a COPY instruction, it replaces the COPY instruction with a predetermined set of source statements from a library. These statements then become a part of the source module. See "COPY—Copy Predefined Source Coding" on page 138 for more details.

Beginning of a Source Module

The first statement of a source module can be any assembler language statement, except MEXIT and MEND, described in this manual. You can initiate the first control section of a source module by using the START instruction. However, you can write some source statements before the beginning of the first control statement. See "First Control Section" on page 49 for more details.

End of a Source Module

The END instruction usually marks the end of a source module. However, you can code several END instructions. The assembler stops assembling when it processes the first END instruction. If no END instruction is found, the assembler will generate one. See "END—End Assembly" on page 139 for more details.

Note: Conditional assembly processing can determine which of several substituted END instructions is to be processed.

CONTROL SECTIONS

A control section is the smallest subdivision of a program that can be relocated as a unit. The assembled control sections contain the object code for machine instructions, data constants, and areas.

Consider the concept of a control section at different processing times.

At coding time: You create a control section when you write the instructions it contains. In addition, you establish the addressability of each control section within the source module, and provide any symbolic linkages between control sections that lie in different source modules. You also write the linkage editor control statements to combine the desired control sections into a load module, and to provide an entry point address for the beginning of program execution.

At assembly time: The assembler translates the source statements in the control section into object code. Each source module is assembled into one object module. The entire object module and each of the control sections it contains are relocatable.

At link-editing time: According to linkage editor control statements, the linkage editor combines the object code of one or more control sections into one load module. It also calculates the linkage addresses necessary for communication between two or more control sections from different object modules. In addition, it calculates the space needed to accommodate external dummy sections.

At program fetch time: The control program loads the load module into virtual storage. All the relocatable addresses are converted to fixed locations in storage.

At execution time: The control program passes control to the load module now in virtual storage, and your program is executed.

Note: You can specify the relocatable address of the starting point for program execution in a link-edit control statement or in the operand field of an END statement.

Executable Control Sections

An executable control section is one you initiate by using the START or CSECT instruction, and is assembled into object code. At execution time, an executable control section contains the binary data assembled from your coded instructions and constants, and is, therefore, executable.

An executable control section can also be initiated as "private code," without using the START or CSECT instruction.

Reference Control Sections

A reference control section is one you initiate by using the DSECT, COM, or DXD instruction, and is not assembled into object code. You can use a reference control section either to reserve storage areas or to describe data to which you can refer from executable control sections. These reference control sections are considered to be empty at assembly time, and the actual binary data to which they refer is not entered until execution time.

LOCATION COUNTER SETTING

The assembler maintains a separate location counter for each control section. The location counter setting for each control section starts at 0. The location values assigned to the instructions and other data in a control section are, therefore, relative to the location counter setting at the beginning of that control section.

However, for executable control sections, the location values that appear in the listings do not restart at 0 for each subsequent executable control section. They carry on from the end of the previous control section. Your executable control sections are usually loaded into storage in the order in which you write them. You can, therefore, match the source statements and object code produced from them with the contents of a dump of your program.

For reference control sections, the location values that appear in the listings always start from 0.

You can continue a control section that has been discontinued by another control section, and, thereby, intersperse code sequences from different control sections. Note that the

location values that appear in the listings for a control section, divided into segments, follow from the end of one segment to the beginning of the subsequent segment.

The location values listed for the next control section defined, begin after the last location value assigned to the preceding control section.

Use of Multiple Location Counters

Assembler H allows you to use multiple location counters for each individual control section. You use the LOCTR instruction (whose format and specifications are described below) to assign different location counters to different parts of a control section. The assembler will then rearrange and assemble the coding together, according to the different location counters you have specified: All coding using the first location counter will be assembled together, then the coding using the second location counter will be assembled together, etc.

A practical use of multiple location counters is illustrated in Figure 14. There, executable instructions and data areas have been interspersed throughout the coding in their logical sequence, each group of instructions preceded by a LOCTR instruction identifying the location counter under which it is to be assembled. The assembler will rearrange the control section so that the executable instructions are grouped together and the data areas together.

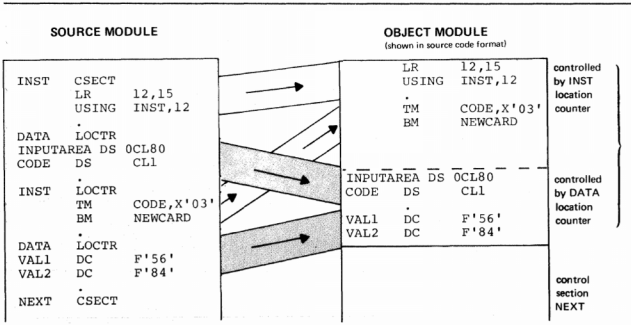


Figure 14. Use of Multiple Location Counters

LOCTR—Multiple Location Counters

The LOCTR instruction allows you to specify multiple location counters within a control section. The assembler assigns consecutive addresses to the segments of code using one location

counter before it assigns addresses to segments of coding using the next location counter.

The format for the LOCTR instruction is:

Name	Operation	Operand
A variable or ordinary symbol	LOCTR	Blank

By using the LOCTR instruction, you can code your control section in a logical order. For example, you can code work areas and data constants within the section of code, using them without having to branch around them.

```
(1) A    CSECT
         LR      12,15
         USING   A,12
(2) B    LOCTR
         .
    C    LOCTR
         .
(3) B    LOCTR
         .
(4) A    LOCTR
         .
(1) DUM  DSECT
(5) C    LOCTR
         .
         END
```

(1) The first location counter of a control section is defined by the name of the START, CSECT, DSECT, or COM instruction defining the section.

(2) The LOCTR instruction defines a location counter or (3) resumes a previously defined location counter. A location counter remains in use until it is interrupted by a LOCTR, CSECT, DSECT, or COM instruction.

(4) A LOCTR instruction with the same name as a control section resumes the first location counter of that section.

(5) A LOCTR instruction with the same name as a LOCTR instruction in a previous control section causes that control section to be resumed using the location counter specified.

A control section cannot have the same name as a previous LOCTR instruction. A LOCTR instruction placed before the first control section definition will initiate an unnamed control section before the LOCTR instruction is processed.

The length attribute of a LOCTR name is 1.

LOCTR instructions do not force alignment; code running under a location counter other than the first location counter of a control section will be assembled starting at the next available byte after the previous segment.

FIRST CONTROL SECTION

The specifications below apply to the first executable control section, and not to a reference control section.

Instructions that establish the first control section: Any instruction that affects the location counter, or uses its current value, establishes the beginning of the first executable control section. The instructions that establish the first control section include any machine instruction and the following assembler instructions:

```
CCW, CCW0, and CCW1
CNOP
(COPY)
CSECT
CXD
DC
DROP
DS
END
EQU
LTORG
ORG
START
USING
```

Notes:

1. These instructions are always considered a part of the control section in which they appear.
2. The statements copied into a source module by a COPY instruction determine whether it will initiate the first control section.
3. The DSECT, COM, and DXD instructions initiate reference control sections and do not establish the first executable control section.

What must come before the first control section: The following instructions or macro definitions, if specified, belong to a source module, but must appear before the first control section:

- The ICTL instruction, which, if specified, must be the first statement in a source module
- The OPSYN instruction
- Any source macro definitions
- The COPY instruction, if the code to be copied contains only OPSYN instructions or complete macro definitions

What can optionally come before the first control section: The instructions or groups of instructions that can optionally be specified before the first control section are listed below:

- The following assembler instructions:

  ```
  COPY
  DXD
  EJECT
  ENTRY
  EXTRN
  ISEQ
  PRINT
  PUNCH
  REPRO
  SPACE
  TITLE
  WXTRN
  ```

- Comments statements
- Common control sections
- Dummy control sections

- External dummy control sections
- Any conditional assembly instruction
- Macro instructions

Notes:

1. The above instructions or groups of instructions belong to a source module, but are not considered as part of an executable control section.
2. Any instructions copied by a COPY instruction, or generated by the processing of a macro instruction before the first control section, must belong exclusively to one of the groups of instructions shown above.
3. The EJECT, ISEQ, OPSYN, PRINT, SPACE, or TITLE instructions and comments statements must follow the ICTL instruction, if specified.
4. All the instructions or groups of instructions listed above can also appear as part of a control section.

UNNAMED CONTROL SECTION

The unnamed control section is an executable control section that can be initiated in one of the following two ways:

- By coding a START or CSECT instruction without a name entry
- By coding any instruction, other than the START or CSECT instruction, that initiates the first executable control section

The unnamed control section is sometimes referred to as private code.

All control sections ought to be provided with names so that they can be referred to symbolically:

- Within a source module
- In EXTRN and WXTRN instructions and linkage editor control statements for linkage between source modules

Notes:

1. Unnamed common control sections or dummy control sections can be defined if the name entry is omitted from a COM or DSECT instruction.
2. If you include an AMODE or RMODE instruction in this assembly and leave the name field blank, you must provide an unnamed control section.

LITERAL POOLS IN CONTROL SECTIONS

Literals, collected into pools by the assembler, are assembled as part of the executable control section to which the pools belong. If a LTORG instruction is specified at the end of each control section, the literals specified for that section will be assembled into the pool starting at the LTORG instruction. If no LTORG instruction is specified, a literal pool containing all the literals used in the entire source module is assembled at the end of the first control section. This literal pool appears in the listings after the END instruction.

Note: If any control section is divided into segments, a LTORG instruction should be specified at the end of each segment to create a separate literal pool for that segment.

EXTERNAL SYMBOL DICTIONARY ENTRIES

The assembler keeps a record of each control section and prints the following information about it in an external symbol dictionary (ESD):

1. Symbolic name, if one is specified
2. Type code
3. Individual identification
4. Starting address

Figure 15 on page 53 lists the assembler instructions that define control sections and dummy control sections (see 1 in figure), or identify entry and external symbols (see 2 in figure), and tells their associated type codes. There is no limit to the number of individual control sections and external symbols that can be defined in a source module.

ESTABLISHING RESIDENCE AND ADDRESSING MODE

You may specify the addressing mode (AMODE) and/or the residence mode (RMODE) to be associated with control sections in the object deck. These modes may be specified for the following types of control sections:

- Control section (ESD type code 00)
- Unnamed control section (ESD type code 04)
- Common control section (ESD type code 05)

The assembler will set the AMODE and/or RMODE indicators in the ESD record for each applicable control section in an assembly, for passage to the linkage editor and loader. The linkage editor and loader will ensure that control is given to programs with the right addressing mode, and that programs are loaded into the correct part of virtual storage.

Note: The specification of AMODE and RMODE through CMS to the assembler is supported in all levels of VM. However, the resultant object deck produced by the assembler will not be supported through the CMS loader, but may be supported by a virtual machine under VM/XA Migration Aid that has a loader compatible with that object code (for example, MVS/XA loader).

Name Entry		Instruction	Type code entered into external symbol dictionary
optional		START	SD (if name entry is present)
		CSECT	SD (if name entry is present)
		START	PC (if name entry is omitted)
		CSECT	PC (if name entry is omitted)
		Any instruction that initiates the unnamed control section	PC
optional	1	COM	CM
optional	1	DSECT	none
mandatory		DXD	XD
		(external DSECT)	XD
	2	ENTRY	LD
	2	EXTRN	ER
	2	DC(V-type address constant)	ER
	2	WXTRN	WX

Figure 15. Defining CSECTs, DSECTs, and Symbols

AMODE—Addressing Mode

The AMODE instruction allows you to specify the addressing mode to be associated with control sections in the object deck. The format of the statement is as follows:

Name	Operation	Operand
Any symbol or blank	AMODE	24|31|ANY

The name field associates the addressing mode with a control section. If there is a symbol in the name field, it must also appear in the name field of a START, CSECT, or COM instruction in this assembly. If the name field is blank, there must be an unnamed control section in this assembly. If the name field contains a sequence symbol (see "Symbols" on page 21for details), it is treated as a blank name field.

The operand indicates which addressing mode is to be associated with the control section identified by the name field. The operand must be specified as one of the three values shown. The values cannot be replaced by expressions. The values specify the following:

24 specifies that a 24-bit addressing mode is to be associated with a control section.

31 specifies that a 31-bit addressing mode is to be associated with a control section.

ANY specifies that the control section is not sensitive to addressing mode.

Any field of this instruction may be generated by a macro, or by substitution in open code.

Notes:

1. AMODE can be specified anywhere in the assembly. It does not initiate an unnamed control section.
2. An assembly can have multiple AMODE instructions; however, two AMODE instructions cannot have the same name field.
3. Specification of AMODE 24 and RMODE ANY for the same name field is invalid. All other combinations are valid.
4. AMODE or RMODE cannot be specified for an unnamed common control section.
5. The defaults when AMODE and RMODE are not both specified for a name field are as follows:

Specified	Defaulted
Neither	AMODE 24, RMODE 24
AMODE 24	RMODE 24
AMODE 31	RMODE 24
AMODE ANY	RMODE 24
RMODE 24	AMODE 24
RMODE ANY	AMODE 31

RMODE—Residence Mode

The RMODE instruction allows you to specify the residence mode to be associated with control sections in the object deck. The format of the statement is as follows:

Name	Operation	Operand
Any symbol or blank	RMODE	24|ANY

The name field associates the residence mode with a control section. If there is a symbol in the name field, it must also appear in the name field of a START, CSECT, or COM instruction in this assembly. If the name field is blank, there must be an unnamed control section in this assembly. If the name field contains a sequence symbol (see "Symbols" on page 21for details), it is treated as a blank name field.

The operand indicates which residence mode is to be associated with the control section identified by the name field. The operand must be specified as one of the two values shown. The values cannot be replaced by expressions. The values specify the following:

24 specifies that a residence mode of 24 is to be associated with the control section; that is, the control section must be resident below 16 megabytes.

ANY specifies that a residence mode of either 24 or 31 is to be associated with the control section; that is, the control section can be resident above or below 16 megabytes.

Any field of this instruction may be generated by a macro, or by substitution in open code.

Notes:

1. RMODE can be specified anywhere in the assembly. It does not initiate an unnamed control section.
2. An assembly can have multiple RMODE instructions; however, two RMODE instructions cannot have the same name field.
3. Specification of AMODE 24 and RMODE ANY for the same name field is invalid. All other combinations are valid.
4. AMODE or RMODE cannot be specified for an unnamed common control section.
5. The defaults when AMODE and RMODE are not both specified for a name field are as follows:

Specified	Defaulted
Neither	AMODE 24, RMODE 24
AMODE 24	RMODE 24
AMODE 31	RMODE 24
AMODE ANY	RMODE 24
RMODE 24	AMODE 24
RMODE ANY	AMODE 31

DEFINING A CONTROL SECTION

You must use the instructions described below to indicate to the assembler:

- Where a control section begins
- Which type of control section is being defined

START—Start Assembly

The START instruction can be used only to initiate the first or only control section of a source module. You should use the START instruction for this purpose, because it allows you:

- To determine exactly where the first control section is to begin; you thereby avoid the accidental initiation of the first control section by some other instruction
- To give a symbolic name to the first control section, which can then be distinguished from the other control sections listed in the external symbol dictionary
- To specify the initial setting of the location counter for the first or only control section

The START instruction must be the first instruction of the first executable control section of a source module. It must not be preceded by any instruction that affects the location counter, and thereby causes the first control section to be initiated.

The format of the START instruction statement is:

Name	Operation	Operand
Any symbol or blank	START	A self-defining term, an absolute expression, or blank

Note: If the operand of a START instruction is an absolute expression, any symbols referenced in it must have been previously defined.

The symbol in the name field, if specified, identifies the first control section. It must be used in the name field of any CSECT instruction that indicates the continuation of the first control section. This symbol represents the address of the first byte of the control section, and has a length attribute value of 1.

The assembler uses the value of the self-defining term or absolute expression in the operand field, if specified, to set the location counter to an initial value for the source module.

All control sections are aligned on a doubleword boundary. Therefore, if the value specified in the operand is not divisible by 8, the assembler sets the initial value of the location counter to the next higher doubleword boundary. If the operand entry is omitted, the assembler sets the initial value to 0.

The source statements that follow the START instruction are assembled into the first control section. If a CSECT instruction indicates the continuation of the first control section, the source statements that follow this CSECT instruction are also assembled into the first control section.

Any instruction that defines a new or continued control section marks the end of the preceding control section. The END instruction marks the end of the control section in effect.

CSECT—Identify Control Section

The CSECT instruction allows you to initiate an executable control section or indicate the continuation of an executable control section.

The CSECT instruction can be used anywhere in a source module after any source macro definitions that are specified. If it is used to initiate the first executable control section, it must not be preceded by any instruction that affects the location

counter and thereby cause the first control section to be initiated.

The format of the statement is as follows:

Name	Operation	Operand
Any symbol or blank	CSECT	Not required

The symbol in the name field, if specified, identifies the control section. If several CSECT instructions within a source module have the same symbol in the name field, the first occurrence initiates the control section, and the rest indicate the continuation of the control section. If the first control section is initiated by a START instruction, the symbol in the name field must be used to indicate any continuation of the first control section.

Note: A CSECT instruction with a blank name field either initiates or indicates the continuation of the unnamed control section.

The symbol in the name field represents the address of the first byte of the control section, and has a length attribute value of 1.

The beginning of a control section is aligned on a doubleword boundary. However, when an interrupted control section is resumed using the CSECT instruction, the location counter last specified in that control section will be resumed. Consider the coding in Figure 16.

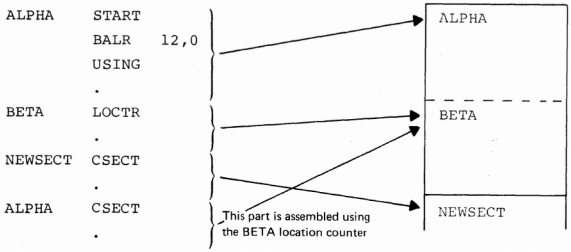


Figure 16. How the Location Counter Works

The source statements following a CSECT instruction that either initiate or indicate the continuation of a control section are assembled into the object code of the control section identified by that CSECT instruction.

Note: The end of a control section or portion of a control section is marked by (a) any instruction that defines a new or continued control section, or (b) the END instruction.

DSECT—Identify Dummy Section

You can use the DSECT instruction to initiate a dummy control section or to indicate its continuation.

A dummy control section is a reference control section that allows you to describe the layout of data in a storage area without actually reserving any virtual storage.

You may wish to describe the format of an area whose storage location will not be determined until the program is executed. You can do so by describing the format of the area in a dummy section, and using symbols defined in the dummy section as the operands of machine instructions.

How to use a dummy control section: A dummy control section (dummy section) allows you to write a sequence of assembler language statements to describe the layout of unformatted data located elsewhere in your source module. The assembler produces no object code for statements in a dummy control section, and it reserves no storage for it. Rather, the dummy section provides a symbolic format that is empty of data. However, the assembler assigns location values to the symbols you define in a dummy section, relative to its beginning.

Therefore, to use a dummy section, you must:

- Reserve a storage area for the unformatted data
- Ensure that this data is loaded into the area at execution time
- Ensure that the locations of the symbols in the dummy section actually correspond to the locations of the data being described
- Establish the addressability of the dummy section in combination with the storage area

You can then refer to the unformatted data symbolically by using the symbols defined in the dummy section.

The DSECT instruction identifies the beginning or continuation of a dummy control section. One or more dummy sections can be defined in a source module.

The DSECT instruction can be used anywhere in a source module after the ICTL instruction, or after any source macro definitions that may be specified. The format of the DSECT instruction statement is:

Name	Operation	Operand
Any symbol or blank	DSECT	Not required

The symbol in the name field, if specified, identifies the dummy section. If several DSECT instructions within a source module have the same symbol in the name field, the first occurrence initiates the dummy section, and the rest indicate the continuation of the dummy section.

Note: A DSECT instruction with a blank name field either initiates or indicates the continuation of the unnamed dummy section.

The symbol in the name field represents the first location in the dummy section, and has a length attribute value of 1.

The location counter for a dummy section is always set to an initial value of 0. However, when an interrupted dummy control

section is resumed using the DSECT instruction, the location counter last specified in that control section will be resumed.

The source statements that follow a DSECT instruction belong to the dummy section identified by that DSECT instruction.

Notes:

1. The assembler language statements that appear in a dummy section are not assembled into object code.

2. When establishing the addressability of a dummy section, the symbol in the name field of the DSECT instruction, or any symbol defined in the dummy section can be specified in a USING instruction.

3. A symbol defined in a dummy section can be specified in an address constant only if the symbol is paired with another symbol from the same dummy section, and if the symbols have the opposite sign.

To effect references to the storage area defined by a dummy section, do the following:

- Provide a USING statement specifying both a general register that the assembler can assign to the machine instructions as a base register and a value from the dummy section that the assembler may assume the register contains.

- Ensure that the same register is loaded with the actual address of the storage area.

The values assigned to symbols defined in a dummy section are relative to the initial statement of the section. Thus, all machine instructions that refer to names defined in the dummy section will, at execution time, refer to storage locations relative to the address loaded into the register.

An example is shown in the following coding. Assume that two independent assemblies (assembly 1 and assembly 2) have been loaded and are to be executed as a single overall program. Assembly 1 is an input routine that places a record in a specified area of storage, places the address of the input area containing the record in general register 3, and branches to assembly 2. Assembly 2 processes the record. The coding shown in the example is from assembly 2.

The input area is described in assembly 2 by the DSECT control section named INAREA. Portions of the input area that you want to work with are named in the DSECT control section as shown. The assembler instruction USING INAREA,3 designates general register 3 as the base register to be used in addressing the DSECT control section, and that general register 3 is assumed to contain the address of INAREA.

Assembly 1, during execution, loads the actual beginning address of the input area in general register 3. Because the symbols used in the DSECT section are defined relative to the initial statement in the section, the address values they represent will, at the time of program execution, be the actual storage locations of the input area.

Name	Operation	Operand
ASMBLY2	CSECT	
BEGIN	BALR	2,0
	USING	*,2
	.	
	.	
	USING	INAREA,3
	CLI	INCODE,C'A'
	BE	ATYPE
	.	
	.	
ATYPE	MVC	WORKA,INPUTA
	MVC	WORKB,INPUTB
	.	
	.	
WORKA	DS	CL20
WORKB	DS	CL18
	.	
	.	
INAREA	DSECT	
INCODE	DS	CL1
INPUTA	DS	CL20
INPUTB	DS	CL18
	.	
	END	

COM—Define Blank Common Control Section

You can use the COM instruction to initiate a common control section, or to indicate its continuation. One or more common sections can be defined in a source module. A common control section is a reference control section that allows you to reserve a storage area that can be used by two or more source modules.

How to use a common control section: A common control section (common section) allows you to describe a common storage area in one or more source modules.

When the separately assembled object modules are linked as one program, the required storage space is reserved for the common control section. Thus, two or more modules share the common area.

Only the storage area is provided; the assembler does not assemble the source statements that make up a common control section into object code. You must provide the data for the common area at execution time.

The assembler assigns locations to the symbols you define in a common section relative to the beginning of that common section. This allows you to refer symbolically to the data that will be loaded at execution time. Note that you must establish the addressability of a common control section in every source module in which it is specified. If you code identical common sections in two or more source modules, you can communicate data symbolically between these modules through this common section.

Note: You can also code a common control section in a source module written in the FORTRAN language. This allows you to communicate between assembler language modules and FORTRAN modules.

The COM instruction identifies the beginning or continuation of a common control section.

The COM instruction can be used anywhere in a source module after the ICTL instruction, or after any source macro definitions that may be specified.

The format of the COM instruction statement is:

Name	Operation	Operand
Any symbol or blank	COM	Not required

The symbol in the name field, if specified, identifies the common control section. If several COM instructions within a source module have the same symbol in the name field, the first occurrence initiates the common section and the rest indicate the continuation of the common section.

Note: A COM instruction with a blank name field either initiates or indicates the continuation of the unnamed common section.

The symbol in the name field represents the address of the first byte in the common section, and has a length attribute value of 1.

The location counter for a common section is always set to an initial value of 0. However, when an interrupted common control section is resumed using the COM instruction, the location counter last specified in that control section will be resumed.

If a common section with the same name (or unnamed) is specified in two or more source modules, the amount of storage reserved for this common section is equal to that required by the longest common section specified.

The source statements that follow a COM instruction belong to the common section identified by that COM instruction.

Notes:

1. The assembler language statements that appear in a common control section are not assembled into object code.

2. When establishing the addressability of a common section, the symbol in the name field of the COM instruction, or any symbol defined in the common section, can be specified in a USING instruction.

In the following example, addressability to the common area of storage is established relative to the named statement XYZ.

Name	Operation	Operand
	. . L USING MVC . . COM	 1,=A(XYZ) XYZ,1 PDQ(16),=4C'ABCD'
XYZ PDQ	DS DS . .	16F 16C

No instructions or constants appearing in a common control section are assembled. Data can only be placed in a common control section through execution of the program. A blank common control section may include any assembler language instructions.

If the assignment of common storage is done in the same manner by each independent assembly, reference to a location in common

by any assembly results in the same location being referenced. When the blank common control section is assembled, the initial value of the location counter is set to zero.

EXTERNAL DUMMY SECTIONS

An external dummy section is a reference control section that allows you to describe storage areas for one or more source modules, to be used as:

- Work areas for each source module, or
- Communication areas between two or more source modules

When the assembled object modules are linked and loaded, you can dynamically allocate the storage required for all your external dummy sections at one time from one source module (for example, by using the GETMAIN macro instruction). This is not only convenient, but you save space and prevent fragmentation of virtual storage.

To generate and use the external dummy sections, you need to specify a combination of the following:

- DXD or DSECT instruction
- Q-type address constant
- CXD instruction

Generating an external dummy section: An external dummy section is generated when you specify an DXD instruction or a DSECT instruction in combination with a Q-type address constant that contains the name of the DSECT instruction.

You use the Q-type address constant to reserve storage for the offset to the external dummy section whose name is specified in the operand. This offset is the distance in bytes from the beginning of the area allocated for all the external dummy sections to the beginning of the external dummy section specified. You can use this offset value to address the external dummy section.

Using external dummy sections: To use an external dummy section, you must do the following:

1. Identify and define the external dummy section. The assembler will compute the length and alignment required.
2. Provide a Q-type constant for each external dummy section defined.
3. Use the CXD instruction to reserve a fullword area into which the linkage editor or loader will insert the total length of all the external dummy sections that are specified in the source modules of your program. The linkage editor computes this length from the lengths of the individual external dummy sections supplied by the assembler.
4. Allocate a storage area using the computed total length.
5. Load the address of the allocated area into a register. Note that register 11 must contain this address throughout the whole program.
6. Add to the address in register 11 the offset into the allocated area of the desired external dummy section. The linkage editor inserts this offset into the fullword area reserved by the appropriate Q-type address constant.
7. Establish the addressibility of the external dummy section in combination with the portion of the allocated area reserved for the external dummy section.

You can now refer symbolically to the locations in the external dummy section. Note that the source statements in an external dummy section are not assembled into object code. Thus, at execution time, you must insert the data described into the area reserved for the external dummy sections.

DXD—Define External Dummy Section

The DXD instruction allows you to identify and define an external dummy section. The DXD instruction can be used anywhere in a source module, after the ICTL instruction, or after any source macro definitions that may be specified.

Notes:

1. An external dummy section identified by a DXD instruction will not generate an entry in the external symbol dictionary (ESD) unless it is referenced by a Q-type address constant.

2. The DSECT instruction also defines an external dummy section, but only if the symbol in the name field appears in a Q-type address constant in the same source module. Otherwise, a DSECT instruction defines a dummy section.

The format of the DXD instruction is:

Name	Operation	Operand
A symbol	DXD	Duplication factor, type, modifiers, nominal value

The symbol in the name field must appear in the operand of a Q-type constant. This symbol represents the address of the first byte of the external dummy section defined, and has a length attribute value of 1.

The subfields in the operand field (duplication factor, type, modifier, and nominal value) are specified in the same way as in a DS instruction. The assembler computes the amount of storage and the alignment required for an external dummy section from the area specified in the operand field.

The linkage editor or loader uses the information provided by the assembler to compute the total length of storage required for all external dummy sections specified in a program.

Note: If two or more external dummy sections for different source modules have the same name, the linkage editor uses the most restrictive alignment, and the largest section to compute the total length.

CXD—Cumulative Length External Dummy Section

The CXD instruction allows you to reserve a fullword area in storage. The linkage editor or loader will insert into this area the total length of all external dummy sections specified in the source modules that are assembled and linked into one program.

The format for the CXD instruction is:

Name	Operation	Operand
Any symbol or blank	CXD	Not required

The symbol in the name field, if specified, represents the address of a fullword area aligned on a fullword boundary. This symbol has a length attribute value of 4. The linkage editor or loader inserts into this area the total length of storage required for all the external dummy sections specified in a program.

The following example shows how external dummy sections may be used.

ROUTINE A

Name	Operation	Operand
ALPHA	DXD	2DL8
BETA	DXD	4FL4
OMEGA	CXD	
	.	
	.	
	DC	Q(ALPHA)
	DC	Q(BETA)
	.	
	.	

ROUTINE B

Name	Operation	Operand
GAMMA	DXD	5D
DELTA	DXD	10F
	.	
	.	
	DC	Q(GAMMA)
	DC	Q(DELTA)
	.	
	.	

ROUTINE C

Name	Operation	Operand
EPSILON	DXD	4H
	.	
	.	
	DC	Q(EPSILON)
	.	
	.	

Each of the three routines is requesting an amount of work area. Routine A wants 2 doublewords and 4 fullwords; Routine B wants 5 doublewords and 10 fullwords; Routine C wants 4 halfwords. At the time these routines are brought into storage, the sum of the individual lengths will be placed in the location of the CXD instruction labeled OMEGA. Routine A can then allocate the amount of storage that is specified in the CXD location.

SYMBOLIC LINKAGES

Symbols may be defined in one module and referred to in another, thus effecting symbolic linkages between independently assembled program sections. The linkages can be effected only if the assembler is able to provide information about the linkage symbols to the linkage editor, which resolves these linkage references at load time.

Establishing symbolic linkage: You must establish symbolic linkage between source modules so that you can refer or branch to symbolic locations defined in the control sections of external source modules. To establish symbolic linkage with an external source module, you must do the following:

- In the current source module, you must identify the symbols that are not defined in that source module, if you wish to use them in instruction operands. These symbols are called external symbols, because they are defined in another (external) source module. You identify external symbols in the EXTRN or WXTRN instruction, or the V-type address constant.
- In the external source modules, you must identify the symbols that are defined in those source modules, and to which you refer from the current source module. These symbols are called entry symbols, because they provide points of entry to a control section in a source module. You identify entry symbols with the ENTRY instruction.
- You must provide the A-type or V-type address constants needed by the assembler to reserve storage for the addresses represented by the external symbols.

The assembler places information about entry and external symbols in the external symbol dictionary. The linkage editor uses this information to resolve the linkage addresses identified by the entry and external symbols.

Referring to external data: You should use the EXTRN instruction to identify the external symbol that represents data in an external source module, if you wish to refer to this data symbolically.

For example, you can identify the address of a data area as an external symbol and load the address constant specifying this symbol into a base register. Then, you use this base register when establishing the addressability of a dummy section that formats this external data. You can now refer symbolically to the data that the external area contains.

You must also identify, in the source module that contains the data area, the address of the data as an entry symbol.

Branching to an external address: You should use the V-type address constant to identify the external symbol that represents the address in an external source module to which you wish to branch.

For example, you can load into a register the V-type address constant that identifies the external symbol. Using this register, you can then branch to the external address represented by the symbol.

If the symbol is the name entry of a START or CSECT instruction in the other source module, and thus names an executable control section, it is automatically identified as an entry symbol. If the symbol represents an address in the middle of a control section, you must identify it as an entry symbol for the external source module.

You can also use a combination of an EXTRN instruction to identify, and an A-type address constant to contain, the external branch address. However, the V-type address constant is more convenient because:

- You do not have to use an EXTRN instruction.
- The symbol identified is not considered as defined in the source module, and can be used as the name entry for any other statement in the same source module.

ENTRY—Identify Entry-Point Symbol

The ENTRY instruction allows you to identify symbols defined in one source module so that they can be referred to in another source module. These symbols are entry symbols.

The format for the ENTRY instruction is:

Name	Operation	Operand
A sequence symbol or blank	ENTRY	One or more relocatable symbols, separated by commas

The following applies to the entry symbols identified in the operand field:

- They must be valid symbols.
- They must be defined in an executable control section.
- They must not be defined in a dummy control section, a common control section, or an external control section.
- The length attribute value of entry symbols is the same as the length attribute value of the symbol at its point of definition.

A symbol used as the name entry of a START or CSECT instruction is also automatically considered an entry symbol, and does not have to be identified by an ENTRY instruction.

The assembler lists each entry symbol of a source module in an external symbol dictionary, along with entries for external symbols, common control sections, and external control sections.

There is no restriction on the number of control sections, external symbols, and external dummy sections allowed by the assembler. The maximum number depends on the amount of main storage available during link editing.

EXTRN—Identify External Symbol

The EXTRN instruction allows you to identify symbols referred to in a source module but defined in another source module. These symbols are external symbols.

The format of the EXTRN statement is:

Name	Operation	Operand
A sequence symbol or blank	EXTRN	One or more relocatable symbols, separated by commas

EXTERNAL SYMBOLS: The following applies to the external symbols identified in the operand field:

- They must be valid symbols.
- They must not be used as the name entry of a source statement in the source module in which they are identified.
- They have a length attribute value of 1.
- They must be used alone and cannot be paired when used in an expression.

The assembler lists each external symbol identified in a source module in the external symbol dictionary, along with entries for entry symbols, common control sections, and external control sections.

There is no restriction on the number of control sections, external symbols, and external dummy sections allowed by the assembler. The maximum number depends on the amount of main storage available during link editing.

WXTRN—Identify Weak External Symbol

The WXTRN statement allows you to identify symbols referred to in a source module but defined in another source module. The WXTRN instruction differs from the EXTRN instruction as follows:

- The EXTRN instruction causes the linkage editor to make an automatic search of libraries to find the module that contains the external symbols that you identify in its operand field. If the module is found, linkage addresses are resolved; the module is then linked to your module, which contains the EXTRN instruction.
- The WXTRN instruction suppresses this automatic search of libraries. The linkage editor will only resolve the linkage addresses if the external symbols that you identify in the WXTRN operand field are defined:
  - In a module that is linked and loaded along with the object module assembled from your source module, or
  - In a module brought in from a library because of the presence of an EXTRN instruction in another module linked and loaded with yours.

The format of the WXTRN instruction is:

Name	Operation	Operand
A sequence symbol or blank	WXTRN	one or more relocatable symbols separated by commas

The external symbols identified by a WXTRN instruction have the same properties as the external symbols identified by the EXTRN instruction. However, the type code assigned to these external symbols differs.

Note: If a symbol, specified in a V-type address constant, is also identified by a WXTRN instruction, it is assigned the same type code as the symbol in the WXTRN instruction.

If an external symbol is identified by both an EXTRN and WXTRN instruction in the same source module, the first declaration takes precedence, and subsequent declarations are flagged with warning messages.

CHAPTER 4. MACHINE INSTRUCTION STATEMENTS

This chapter introduces the main functions of the machine instructions and provides general rules for coding them in their symbolic assembler language format. For the complete specifications of machine instructions, their object code format, their coding specifications, and their use of registers and virtual storage areas, see the appropriate principles of operation manual for your processor.

At assembly time, the assembler converts the symbolic assembler language representation of the machine instructions to the corresponding object code. It is this object code that the computer processes at execution time. Thus, the functions described in this section can be called execution time functions.

Also at assembly time, the assembler creates the object code of the data constants and reserves storage for the areas you specify in your DC and DS assembler instructions (see "Data Definition Instructions" on page 90). At execution time, the machine instructions can refer to these constants and areas, but the constants themselves are not executed.

As defined in the appropriate principles of operation manual, there are five categories of machine instructions:

- General instructions
- Decimal instructions
- Floating-Point instructions
- Control instructions
- Input/Output operations

Each is discussed in the following sections.

GENERAL INSTRUCTIONS

You use general instructions to manipulate data that resides in general registers or in storage, or that is introduced from the instruction stream. These instructions include fixed-point, logical, and branching instructions; in addition, they include unprivileged status-switching instructions. Some general instructions operate on data that resides in the PSW or the TOD clock.

The general instructions treat data as being of four types: signed binary integers, unsigned binary integers, unstructured logical data, and decimal data. Data is treated as decimal by the conversion, packing, and unpacking instructions.

For further information, see "General Instructions" in the appropriate principles of operation manual.

DECIMAL INSTRUCTIONS

You use the decimal instructions when you wish to perform arithmetic and editing operations on data that has the binary equivalent of decimal representation, either in packed or zoned form. These instructions treat all numbers as integers. For example, 3.14, 31.4, and 314 are all processed as 314. You must keep track of the decimal point yourself.

Additional operations on decimal data are provided by several of the instructions in "General Instructions" in the appropriate

principles of operation manual. Decimal operands always reside in storage, and all decimal instructions use the SS format.

For further information, see "Decimal Instructions" in the appropriate principles of operation manual.

FLOATING-POINT INSTRUCTIONS

You use floating-point instructions when you wish to perform arithmetic operations on binary data that represents both integers and fractions. Thus, you do not have to keep track of the decimal point in your computations. Floating-point instructions also allow you to perform arithmetic operations on both very large numbers and very small numbers, with greater precision than with fixed-point instructions.

For further information, see "Floating-Point Instructions" in the appropriate principles of operation manual.

CONTROL INSTRUCTIONS

Control instructions include all privileged and semiprivileged machine instructions, except the input/output instructions (see below).

Privileged instructions may be executed only when the processor is in the supervisor state. An attempt to execute an installed privileged instruction in the problem state generates a privileged-operation exception.

Semiprivileged instructions are those instructions that can be executed in the problem state when certain authority requirements are met. An attempt to execute an installed semiprivileged instruction in the problem state when the authority requirements are not met generates a privileged-operation exception or some other program-interruption condition depending on the particular requirement that is violated.

For further details, see "Control Instructions" in the appropriate principles of operation manual.

INPUT/OUTPUT OPERATIONS

You can use the input/output instructions (instead of the IBM-suppled system macro instructions) when you wish to control your input and output operations more closely.

The input or output instructions allow you to identify the channel or the device on which the input or output operation is to be performed. However, these are privileged instructions, and you can use them only when the processor is in the supervisor state but not when it is in the problem state.

For more information, see "Input/Output Operations" in the appropriate principles of operation manual.

BRANCHING WITH EXTENDED MNEMONIC CODES

The branching instructions described below allow you to specify a mnemonic code for the condition on which a branch is to occur. Thus, you avoid having to specify the mask value required by the BC and BCR branching instructions. The assembler translates the mnemonic code that represents the condition into the mask value, which is then assembled in the object code of the machine instruction.

The extended mnemonic codes are given in Figure 17 on page 71. They can be used as operation codes for branching instructions, replacing the BC and BCR machine instruction codes (see (1) in Figure 17). Note that the first operand (see (2) in Figure 17) of the BC and BCR instructions must not be present in the operand field (see (3) in Figure 17) of the extended mnemonic branching instructions.

Note: The addresses represented are explicit addresses (see (4) in Figure 17); however, implicit addresses can also be used in this type of instruction.

STATEMENT FORMATS

Machine instructions are assembled into object code according to one of the formats given below:

Basic Format	Length Attribute
E	2
RR	2
RRE	4
RS	4
RX	4
S	4
SI	4
SS	6
SSE	6

When you code machine instructions, you use symbolic formats that correspond to the actual machine language formats. Within each basic format, you can also code variations of the symbolic representation, divided into groups according to the basic formats illustrated below.

The assembler converts only the operation code and the operand entries of the assembler language statement into object code. The assembler assigns to the symbol you code as a name entry the value of the address of the leftmost byte of the assembled instruction. When you use this same symbol in the operand of an assembler language statement, the assembler uses this address value in converting the symbolic operand into its object code form. The length attribute assigned to the symbol depends on the basic machine language format of the instruction in which the symbol appears as a name entry.

A remarks entry is not converted into object code.

An example of a typical assembler language statement follows:

```
LABEL  L  4,256(5,10)  LOAD INTO REG4
```

where

LABEL is the name entry.
L is the operation code (converted to 58).
4 is the register operand (copied).
256(5,10) are the storage operand entries (converted to 5A100).
LOAD INTO REG4 (remarks) is not converted into object code.

The object code of the assembled instruction, in hexadecimal, is:

5845A100 (4 bytes in RX format)

SYMBOLIC OPERATION CODES

You must specify an operation code for each machine instruction statement. The symbolic operation code indicates the type of operation to be performed; for example, A indicates the addition operation. See Appendix D, "Macro Language Summary" for a complete list of symbolic operation codes; see the appropriate

Extended Code		Meaning	Format	(Symbolic) Machine Instruction Equivalent	
	❸ ❹			❶	❷
B	D2(X2,B2)	Unconditional Branch	RX	BC	15,D2(X2,B2)
BR	R2		RR	BCR	15,R2
NOP	D2(X2,B2)	No Operation	RX	BC	0,D2(X2,B2)
NOPR	R2		RR	BCR	0,R2
		Used After Compare Instructions			
BH	D2(X2,B2)	Branch on High	RX	BC	2,D2(X2,B2)
BHR	R2		RR	BCR	2,R2
BL	D2(X2,B2)	Branch on Low	RX	BC	4,D2(X2,B2)
BLR	R2		RR	BCR	4,R2
BE	D2(X2,B2)	Branch on Equal	RX	BC	8,D2(X2,B2)
BER	R2		RR	BCR	8,R2
BNH	D2(X2,B2)	Branch on Not High	RX	BC	13,D2(X2,B2)
BNHR	R2		RR	BCR	13,R2
BNL	D2(X2,B2)	Branch on Not Low	RX	BC	11,D2(X2,B2)
BNLR	R2		RR	BCR	11,R2
BNE	D2(X2,B2)	Branch on Not Equal	RX	BC	7,D2(X2,B2)
BNER	R2		RR	BCR	7,R2
		Used After Arithmetic Instructions			
BO	D2(X2,B2)	Branch on Overflow	RX	BC	1,D2(X2,B2)
BOR	R2		RR	BCR	1,R2
BP	D2(X2,B2)	Branch on Plus	RX	BC	2,D2(X2,B2)
BPR	R2		RR	BCR	2,R2
BM	D2(X2,B2)	Branch on Minus	RX	BC	4,D2(X2,B2)
BMR	R2		RR	BCR	4,R2
BNP	D2(X2,B2)	Branch on Not Plus	RX	BC	13,D2(X2,B2)
BNPR	R2		RR	BCR	13,R2
BNM	D2(X2,B2)	Branch on Not Minus	RX	BC	11,D2(X2,B2)
BNMR	R2		RR	BCR	11,R2
BNZ	D2(X2,B2)	Branch on Not Zero	RX	BC	7,D2(X2,B2)
BNZR	R2		RR	BCR	7,R2
BZ	D2(X2,B2)	Branch on Zero	RX	BC	8,D2(X2,B2)
BZR	R2		RR	BCR	8,R2
BNO	D2(X2,B2)	Branch on No Overflow	RX	BC	14,D2(X2,B2)
BNOR	R2		RR	BCR	14,R2
		Used After Test Under Mask Instructions			
BO	D2(X2,B2)	Branch if Ones	RX	BC	1,D2(X2,B2)
BOR	R2		RR	BCR	1,R2
BM	D2(X2,B2)	Branch if Mixed	RX	BC	4,D2(X2,B2)
BMR	R2		RR	BCR	4,R2
BZ	D2(X2,B2)	Branch if Zeros	RX	BC	8,D2(X2,B2)
BZR	R2		RR	BCR	8,R2
BNO	D2(X2,B2)	Branch if Not Ones	RX	BC	14,D2(X2,B2)
BNOR	R2		RR	BCR	14,R2
BNM	D2(X2,B2)	Branch if Not Mixed	RX	BC	11,D2(X2,B2)
BNMR	R2		RR	BCR	11,R2
BNZ	D2(X2,B2)	Branch if Not Zeros	RX	BC	7,D2(X2,B2)
BNZR	R2		RR	BCR	7,R2

D2=displacement,X2=index register,B2=base register,R2=register containing branch address

Figure 17. Extended Mnemonic Codes

principles of operation for the formats of the corresponding machine instructions.

The general format of the machine instruction operation code is:

```
VERB [MODIFIER] [DATA TYPE] [MACHINE FORMAT]
```

The verb must always be present. It usually consists of one or two characters and specifies the operation to be performed. The verb is underscored in the following examples:

```
A    3,AREA
or
MVC  TO,FROM
```

where

A indicates an add operation, and
MV indicates a move operation.

The other items in the operation code are not always present. They include the following (underscores are used to indicate modifiers, data types, and machine formats in the examples below):

- Modifier, which further defines the operation

  ```
  AL  3,AREA          where L indicates a logical operation
  ```

- Type qualifier, which indicates the type of data used by the instruction in its operation

  ```
  CVB 3,BINAREA       where B indicates binary data

  MVC TO,FROM         where C indicates character data

  AE  2,FLTSHRT       where E indicates normalized short
                        floating-point data

  AD  2,FLTLONG       where D indicates normalized long
                        floating-point data
  ```

- Format qualifier, R or I, which indicates that an RR or SI machine instruction format is assembled

  ```
  ADR  2,4            where R indicates an RR instruction

  MVI  FIELD,X'A1'    where I indicates an SI instruction
  ```

OPERAND ENTRIES

You must specify one or more operands in each machine instruction statement to provide the data or the location of the data upon which the machine operation is to be performed. The operand entries consist of one or more fields or subfields, depending on the format of the instruction being coded. They can specify a register, an address, a length, and immediate data.

You can code an operand entry either with symbols or with self-defining terms. You can omit length fields or subfields, which the assembler will compute for you from the other operand entries.

The rules for coding operand entries are:

1. A comma must separate operands.

2. Parentheses must enclose subfields.

3. A comma must separate subfields enclosed in parentheses.

If a subfield is omitted because it is implicit in a symbolic address, the parentheses that would have enclosed the subfield must be omitted.

If two subfields are enclosed in parentheses and separated by commas, the following applies:

- If both subfields are omitted because they are implicit in a symbolic entry, the separating comma and the parentheses that would have been needed must also be omitted.
- If the first subfield is omitted, the comma that separates it from the second subfield must be written, as well as the enclosing parentheses.
- If the second subfield is omitted, the comma that separates it from the first subfield must be omitted; however, the enclosing parentheses must be written.

Note: Blanks must not appear within the operand field, except as part of a character self-defining term, or in the specification of a character literal.

REGISTERS

You can specify a register in an operand for use as an arithmetic accumulator, a base register, an index register, and as a general depository for data to which you wish to refer repeatedly.

You must be careful when specifying a register whose contents have been affected by the execution of another machine instruction, the control program, or an IBM-supplied system macro instruction.

For some machine instructions, you are limited in which registers you can specify in an operand.

The expressions used to specify registers must have absolute values; in general, registers 0 through 15 can be specified for machine instructions. However, the following restrictions on register usage apply:

1. The floating-point registers (0, 2, 4, or 6) must be specified for floating-point instructions.

2. The even-numbered registers (0, 2, 4, 6, 8, 10, 12, 14) must be specified for the following groups of instructions:

   a. The double-shift instructions

   b. The fullword multiply and divide instructions

   c. The move long and compare logical long instructions

3. The floating-point registers 0 and 4 must be specified for the instructions that use extended floating-point data: AXR, SXR, LRDR, MXR, MXDR, MXD, and DXR.

Note: The assembler checks the registers specified in the instruction statements of the above groups. If the specified register does not comply with the stated restrictions, the assembler issues a diagnostic message and does not assemble the instruction.

Register Usage by Machine Instructions

Registers that are not explicitly coded in the symbolic assembler language representation of machine instructions, but are, nevertheless, used by the assembled machine instructions, are divided into two categories:

1. The base registers that are implicit in the symbolic addresses specified. These implicit addresses are described in detail in "Addresses." The registers can be identified by examining the object code of the assembled machine instruction or the USING instruction(s) that assigns base registers for the source module.

2. The registers that are used by machine instructions in their operations, but do not appear even in the assembled object code. They are as follows:

   a. For the double shift and fullword multiply and divide instructions, the odd-numbered register, whose number is one greater than the even-numbered register specified as the first operand.

   b. For the Move Long and Compare Logical Long instructions, the odd-numbered registers, whose number is one greater than the even-numbered registers specified in the two operands.

   c. For the Branch on Index High (BXH) and the Branch on Index Low or Equal (BXLE) instructions, if the register specified for the second operand is an even-numbered register, the next higher odd-numbered register is used to contain the value to be used for comparison.

   d. For the Translate and Test (TRT) instruction, registers 1 and 2 are also used.

   e. For the Load Multiple (LM) and Store Multiple (STM) instructions, the registers that lie between the registers specified in the first two operands.

Register Usage by System

The control program of the IBM System/370 uses registers 0, 1, 13, 14, and 15.

ADDRESSES

You can code a symbol in the name field of a machine instruction statement to represent the address of that instruction. You can then refer to the symbol in the operands of other machine instruction statements. The object code for the IBM System/370 requires that all addresses be assembled in a numeric base-displacement format. This format allows you to specify addresses that are relocatable or absolute.

You must not confuse the concepts of relocatability with the actual addresses that are coded as relocatable, nor with the format of the addresses that are assembled.

DEFINING SYMBOLIC ADDRESSES: You define symbols to represent either relocatable or absolute addresses. You can define relocatable addresses in two ways:

1. By using a symbol as the label in the name field of an assembler language statement

2. By equating a symbol to a relocatable expression

You can define absolute addresses (or values) by equating a symbol to an absolute expression.

REFERRING TO ADDRESSES: You can refer to relocatable and absolute addresses in the operands of machine instruction statements. (Such address references are also called addresses in this manual.) The two ways of coding addresses are:

1. Implicitly; that is, in a form that the assembler must first convert into an explicit base-displacement form before it can be assembled into object code
2. Explicitly; that is, in a form that can be directly assembled into object code

Relocatability of Addresses

Addresses in the base-displacement form are relocatable, because:

- Each relocatable address is assembled as a displacement from a base address and a base register.
- The base register contains the base address.
- If the object module assembled from your source module is relocated, only the contents of the base register need reflect this relocation. This means that the location in virtual storage of your base has changed, and that your base register must contain this new base address.
- Your addresses have been assembled as relative to the base address; therefore, the sum of the displacement and the contents of the base register will point to the correct address after relocation.

Note: Absolute addresses are also assembled in the base-displacement form, but always indicate a fixed location in virtual storage. This means that the contents of the base register must always be a fixed absolute address value regardless of relocation.

Machine or Object Code Format

All addresses assembled into the object code of the IBM System/370 machine instructions have the format given in Figure 18 on page 76 .

The addresses represented have a value that is the sum of a displacement (see (1) in Figure 18) and the contents of a base register (see (2) in Figure 18).

Note: In RX instructions, the address represented has a value that is the sum of a displacement, the contents of a base register, and the contents of an index register (see (3) in Figure 18).

Implicit Address

An implicit address is specified by coding one expression. The expression can be relocatable or absolute. The assembler converts all implicit addresses into their base-displacement form before it assembles them into object code. The assembler converts implicit addresses into explicit addresses only if a USING instruction has been specified. The USING instruction assigns both a base address, from which the assembler computes displacements, and a base register, to contain the base address. The base register must be loaded with the correct base address at execution time. For details on how the USING instruction is used when establishing addressability, thus allowing implicit references, see "Addressing within Source Modules: Establishing Addressability" in "Chapter 6. Introduction to Macro Language."

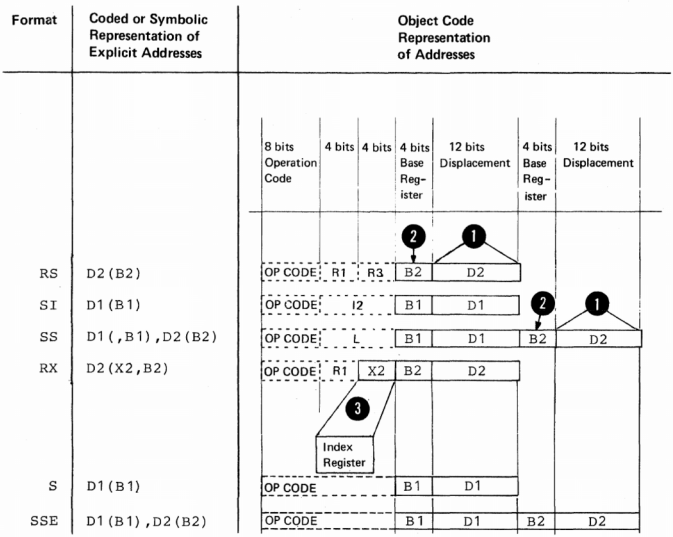


Figure 18. Object Code Format

Explicit Address

An explicit address is specified by coding two absolute expressions as follows:

- The first is an absolute expression for the displacement, whose value must lie in the range 0 through 4095 (4095 is the maximum value that can be represented by the 12 binary bits available for the displacement in the object code).
- The second (enclosed in parentheses) is an absolute expression for the base register, whose value must lie in the range 0 through 15.

If the base register contains a value that changes when the program is relocated, the assembled address is relocatable. If the base register contains a fixed absolute value that is unaffected by program relocation, the assembled address is absolute.

Notes:

1. An explicit base register designation must not accompany an implicit address.
2. However, in RX instructions, an index register can be coded with an implicit address as well as with an explicit address.
3. When two addresses are required, one address can be coded as an explicit address, and the other as an implicit address.

LENGTHS

You can specify the length field in an SS-type instruction. This allows you to indicate explicitly the number of bytes of data at a virtual storage location that is to be used by the instruction. However, you can omit the length specification, because the assembler computes the number of bytes of data to be used from the expression that represents the address of the data.

IMPLICIT LENGTH: When a length subfield is omitted from an SS-type machine instruction, an implicit length is assembled into the object code of the instruction. The implicit length is either of the following:

- For an implicit address, it is the length attribute of the first or only term in the expression representing the implicit address.
- For an explicit address, it is the length attribute of the first or only term in the expression that represents the displacement.

EXPLICIT LENGTH: When a length subfield is specified in an SS-type machine instruction, the explicit length thus defined always overrides the implicit length.

Notes:

1. An implicit or explicit length is the effective length. The length value assembled is always one less than the effective length. If an assembled length value of 0 is desired, an explicit length of 0 or 1 can be specified.
2. In the SS instructions requiring one length value, the allowable range for explicit lengths is 0 through 256. In the SS instructions requiring two length values, the allowable range for explicit lengths is 0 through 16.

IMMEDIATE DATA

In addition to addresses, registers, and lengths, some machine instruction operands require immediate data. Such data is assembled directly into the object code of the machine instructions. You use immediate data to specify the bit patterns for masks or other absolute values you need.

You should be careful to specify immediate data only where it is required. Do not confuse it with address references to constants and areas, or with any literals you specify as the operands of machine instructions.

Immediate data must be specified as absolute expressions whose range of values depends on the machine instruction for which the

data is required. The immediate data is assembled into its 4-bit or 8-bit binary representation.

EXAMPLES OF CODED MACHINE INSTRUCTIONS

The examples that follow are grouped according to machine instruction format. They illustrate the various ways in which you can code the operands of machine instructions. Both symbolic and numeric representation of fields and subfields are shown in the examples. You must, therefore, assume that all symbols used are defined elsewhere in the same source module.

The object code assembled from at least one coded statement per group is also included. A complete summary of machine instruction formats with the coded assembler language variants can be found in Appendix A, "Machine Instruction Format" and the appropriate principles of operation manual.

RR Format

You use the instructions with the RR format mainly to move data between registers. The operand fields must thus designate registers, with the following exceptions:

- In BCR branching instructions, when a 4-bit branching mask replaces the first register specification (see 8 in GAMMA1 instruction below)
- In SVC instructions, where an immediate value (between 0 and 255) replaces both registers (see 200 in DELTA1 instruction below)

Note: Symbols used in RR instructions (see INDEX,REG2 in ALPHA2 instruction below) are assumed to be equated to absolute values between 0 and 15.

Examples of RR format instructions:

Name	Operation	Operand
ALPHA1	LR	1,2
ALPHA2	LR	INDEX,REG2
GAMMA1	BCR	8,12
DELTA1	SVC	200
DELTA2	SVC	TEN

When assembled, the object code of the ALPHA1 instruction, in hexadecimal, is:

```
1812
```

where

```
18 is the operation code.
1 is register R1.
2 is register R2.
```

RRE Format

You use the instructions with the RRE format mainly for control operations. The operand field must designate one or two registers, depending on the specific instruction. If the instruction has only one register operand, then register 2 is assembled as a zero in the object code.

Examples of RRE format instructions:

Name	Operation	Operand
ALPHA1	IPM	REG5
ALPHA2	IPTE	6,7
BETA	DXR	0,4

Note: Symbols used in RRE instructions (such as REG5) are assumed to be equated to absolute values between 0 and 15.

When assembled, the object code of the BETA instruction, in hexadecimal, is:

```
B22D0004
```

where

B22D is the operation code.
00 is zero.
0 is register R1.
4 is register R2.

RS Format

You use the instructions with the RS format mainly to move data between one or more registers and virtual storage, or to compare data in one or more registers.

In the Insert Characters under Mask (ICM) and the Store Characters under Mask (STCM) instructions, a 4-bit mask (see X'E' and MASK in the DELTA instructions below), with a value between 0 and 15, replaces the second register specifications.

Notes:

1. Symbols used to represent registers (see REG4, REG6, and BASE in the ALPHA2 instruction below) are assumed to be equated to absolute values between 0 and 15.
2. Symbols used to represent implicit addresses (see AREA and IMPLICIT in the BETA1 and DELTA2 instructions below) can be either relocatable or absolute.
3. Symbols used to represent displacements (see DISPL in the BETA2 instruction below) in explicit addresses are assumed to be equated to absolute values between 0 and 4095.

Examples of RS format instructions:

Name	Operation	Operand
ALPHA1	LM	4,6,20(12)
ALPHA2	LM	REG4,REG6,20(BASE)
BETA1	STM	4,6,AREA
BETA2	STM	4,6,DISPL(BASE)
GAMMA1	SLL	2,15
GAMMA2	SLL	2,0(15)
DELTA1	ICM	3,X'E',1024(10)
DELTA2	ICM	REG3,MASK,IMPLICIT

When assembled, the object code for the ALPHA1 instruction, in hexadecimal, is:

```
9846C014
```

where

98 is the operation code.
4 is register R1.
6 is register R3.
C is the base register.
014 is the displacement from the base register.

When assembled, the object code for the DELTA1 instruction, in hexadecimal, is:

```
BF3EA400
```

where

BF is the operation code.
3 is register R1.
E is mask M3.
A is the base register.
400 is the displacement from the base register.

RX Format

You use the instructions with the RX format mainly to move data between a register and virtual storage. By adjusting the contents of the index register in the RX instructions, you can change the location in virtual storage being addressed. The operand fields must, therefore, designate registers, including index registers and virtual storage addresses, with the following exception:

In BC branching instructions, a 4-bit branching mask (see 7 and TEN in the LAMBDA instructions below) with a value between 0 and 15, replaces the first register specification

Notes:

1. Symbols used to represent registers (see REG1, INDEX, and BASE in the ALPHA2 instruction below) are assumed to be equated to absolute values between 0 and 15.

2. Symbols used to represent implicit addresses (see IMPLICIT in the GAMMA instructions below) can be either relocatable or absolute.

3. Symbols used to represent displacements (see DISPL in the BETA2 and LAMBDA1 instructions below) in explicit addresses are assumed to be equated to absolute values between 0 and 4095.

Examples of RX format instructions:

Name	Operation	Operand
ALPHA1	L	1,200(4,10)
ALPHA2	L	REG1,200(INDEX,BASE)
BETA1	L	2,200(,10)
BETA2	L	REG2,DISPL(,BASE)
GAMMA1	L	3,IMPLICIT
GAMMA2	L	3,IMPLICIT(INDEX)
DELTA1	L	4,=F'33'
LAMBDA1	BC	7,DISPL(,BASE)
LAMBDA2	BC	TEN,ADDRESS

When assembled, the object code for the ALPHA1 instruction, in hexadecimal, is:

```
5814A0C8
```

where

58 is the operation code.
1 is register R1.
4 is the index register.
A is the base register.
0C8 is the displacement from the base register.

When assembled, the object code for the GAMMA1 instruction, in hexadecimal, is:

5824xyyy

where

58 is the operation code.
2 is register R1.
4 is the index register.
x is the base register.
yyy is the displacement from the base register (IMPLICIT).

S Format

You use the instructions with the S format to perform I/O and other system operations and not to move data in virtual storage.

Examples of S format instructions:

Name	Operation	Operand
GAMMA1	SIO	40(9)
GAMMA2	SIO	0(9)
GAMMA3	SIO	40(0)
GAMMA4	SIO	ZETA

The GAMMA1, GAMMA2, and GAMMA3 instructions specify explicit addresses. The GAMMA4 instruction specifies an implicit address. The GAMMA2 instruction specifies a displacement of zero. The GAMMA3 instruction does not specify a base register.

When assembled, the object code of the GAMMA1 instruction, in hexadecimal, is:

9C009028

where

9C00 is the operation code.
9 is the base register.
028 is the displacement from the base register.

SI Format

You use the instructions with the SI format mainly to move immediate data into virtual storage. The operand fields must, therefore, designate immediate data and virtual storage addresses, with the following exception: An immediate field is not needed (see the GAMMA instructions below) in the statements whose operation codes are LPSW, SSM, TS, TCH, and TIO.

Notes:

1. Symbols used to represent immediate data (see HEX40 and TEN in the ALPHA2 and BETA1 instructions below) are assumed to be equated to absolute values between 0 and 255.

2. Symbols used to represent implicit addresses (see IMPLICIT, KEY, and NEWSTATE in the BETA and GAMMA2 instructions below) can be either relocatable or absolute.

3. Symbols used to represent displacements (see DISPL40 in the ALPHA2 instruction below) in explicit addresses are assumed to be equated to absolute values between 0 and 4095.

Examples of SI format instructions:

Name	Operation	Operand
ALPHA1	CLI	40(9),X'40'
ALPHA2	CLI	DISPL40(NINE),HEX40
BETA1	CLI	IMPLICIT,TEN
BETA2	CLI	KEY,C'E'
GAMMA1	LPSW	0(9)
GAMMA2	LPSW	NEWSTATE

When assembled, the object code for the ALPHA1 instruction, in hexadecimal, is:

```
95409028
```

where

95 is the operation code.
40 is the immediate data.
9 is the base register.
028 is the displacement from the base register.

SS Format

You use the instructions with the SS format mainly to move data between two virtual storage locations. The operand fields and subfields must, therefore, designate virtual storage addresses and the explicit data lengths you wish to include. However, note that, in the Shift and Round Decimal (SRP) instruction, a 4-bit immediate data field (see 3 in SRP instruction below), with a value between 0 and 9, is specified as a third operand.

Notes:

1. Symbols used to represent base registers (see BASE8 and BASE7 in the ALPHA2 instruction below) in explicit addresses are assumed to be equated to absolute values between 0 and 15.

2. Symbols used to represent explicit lengths (see NINE and SIX in the ALPHA2 instruction below) are assumed to be equated to absolute values between 0 and 256 for SS instructions with one length specification, and between 0 and 16 for SS instructions with two length specifications.

3. Symbols used to represent implicit addresses (see FIELD1, FIELD2, and FIELD1,X'8' in the ALPHA3 and SRP instructions below) can be either relocatable or absolute.

4. Symbols used to represent displacements (see DISP40 and DISP30 in the ALPHA5 instruction below) in explicit addresses are assumed to be equated to absolute values between 0 and 4095.

Examples of SS format instructions:

Name	Operation	Operand
ALPHA1	AP	40(9,8),30(6,7)
ALPHA2	AP	40(NINE,BASE8),30(SIX,BASE7)
ALPHA3	AP	FIELD1,FIELD2
ALPHA4	AP	AREA(9),AREA2(6)
ALPHA5	AP	DISP40(,8),DISP30(,7)
BETA1	MVC	0(80,8),0(7)
BETA2	MVC	DISP0(,8),DISP0(7)
BETA3	MVC	TO,FROM
	SRP	FIELD1,X'8',3

When assembled, the object code for the ALPHA1 instruction, in hexadecimal, is:

```
FA858028701E
```

where

```
FA is the operation code.
8 is length L1.
5 is length L2.
8 is base register B1.
028 is the displacement from base register B1.
7 is base register B2.
01E is the displacement from base register B2.
```

When assembled, the object code for the BETA1 instruction, in hexadecimal, is:

```
D24F80007000
```

where

```
D2 is the operation code.
4F is length L.
8 is base register B1.
000 is the displacement from base register B1.
7 is base register B2.
000 is the displacement from base register B2.
```

SSE Format

You use the instructions with the SSE format mainly for control operations. The operand fields designate virtual storage addresses, encoded as base and displacement.

Examples of SSE format instructions:

Name	Operation	Operand
ALPHA1	LASP	40(BASE8),30(BASE7)
ALPHA2	LASP	40(8),30(7)
BETA1	TPROT	LOC1,LOC2
BETA2	TPROT	DISP40(8),DISP30(8)

Notes:

1. Symbols used to represent base registers in explicit addresses (such as BASE8 and BASE7 in the ALPHA1 instruction) are assumed to be equated to absolute values between 0 and 15.

2. Symbols used to represent implicit addresses (such as LOC1,LOC2 in the BETA1 instruction) can either be relocatable or absolute.

3. Symbols used to represent displacements in explicit addresses (such as DISP40 and DISP30 in the BETA2 instruction) are assumed to be equated to absolute values between 0 and 4095.

When assembled, the object code of the ALPHA2 instruction, in hexadecimal, is:

```
E5008028701E
```

where

E500 is the operation code.
8 is base register B1.
028 is the displacement from base register B1.
7 is base register B2.
01E is the displacement from base register B2.

CHAPTER 5. ASSEMBLER INSTRUCTION STATEMENTS

This chapter describes the assembly time functions that you can use.

The following is a list of assembler instructions:

Symbol Definition Instruction

EQU	Equate symbol

Operation Code Definition Instruction

OPSYN	Equate operation code

Data Definition Instructions

DC	Define constant
DS	Define storage
CCW	Define channel command word (Format 0: 24-bit data address)
CCW0	Define channel command word (Format 0: 24-bit data address)
CCW1	Define channel command word (Format 1: 31-bit data address)

Program Sectioning and Linking Instructions (discussed in Chapter 3)

LOCTR	Specify multiple location counters within a control section
START	Start assembly
AMODE	Specify the addressing mode of a control section
RMODE	Specify the residence mode of a control section
CSECT	Identify control section
CXD	Cumulative length of external dummy section
DSECT	Identify dummy section
DXD	Define external dummy section
ENTRY	Identify entry-point symbol
EXTRN	Identify external symbol
WXTRN	Identify weak external symbol
COM	Identify blank common control section

Base Register Instructions (discussed in Chapter 3)

USING	Use base address register
DROP	Drop base address register

Program Control Instructions

ICTL	Input format control
ISEQ	Input sequence checking
PUNCH	Punch a card
REPRO	Reproduce following card
PUSH	Push-down queue for current PRINT or USING
POP	Restore status of current PRINT or USING
ORG	Set location counter
LTORG	Begin literal pool
CNOP	Conditional no operation
COPY	Copy predefined source coding
END	End assembly

Listing Control Instructions

TITLE	Identify assembly output
EJECT	Start new page
SPACE	Space listing
PRINT	Print optional data

EQU—EQUATE SYMBOL

The EQU instruction allows you to assign absolute or relocatable values to symbols. You can use it for the following purposes:

1. To assign single absolute values to symbols.
2. To assign the values of previously defined symbols or expressions to new symbols, thus allowing you to use different mnemonics for different purposes.
3. To compute expressions whose values are unknown at coding time or difficult to calculate. The value of the expressions is then assigned to a symbol.

The EQU instruction can be used anywhere in a source module after the ICTL instruction, or after any source macro definitions that may be specified. Note, however, that the EQU instruction can initiate an unnamed control section (private code) if it is specified before the first control section (initiated by a START or CSECT instruction). The format of the EQU instruction statement is as follows:

Name	Operation	Operand
A variable symbol or ordinary symbol	EQU	Four options: (expression1| expression1,expression2| expression1,expression2, expression3| expression1,,expression3)

Note: The two commas in the last option above indicate the absence of expression 2.

Expression 1 represents a value. It must always be specified and it may assume any value allowed for an assembly expression: Absolute (including negative), relocatable, or complexly relocatable. The assembler carries this value as a signed 4-byte (32-bit) number; all four bytes are printed in the program listings opposite the symbol.

Any symbols used in the first operand (expression 1) need not be previously defined. If the expression in the first operand is complexly relocatable, the whole expression, rather than its value, is assigned to the symbol. During the evaluation of any expression that includes a complexly relocatable symbol, that symbol is replaced by its own defining expression.

Consider the following example, in which A1 and A2 are defined in one control section, and B1 and B2 in another:

Name	Operation	Operand
X	EQU	A1+B1
Y	EQU	X-A2-B2

The first EQU statement assigns a complexly relocatable expression (A1+B1) to X. During the evaluation of the expression in the second EQU statement, X is replaced by its defining relocatable expression (A1+B1), and the assembler evaluates the resulting expression (A1+B1-A2-B2) and assigns an absolute value to Y, because the relocatable terms in the expression are paired.

Expression 2 represents a length attribute. It is optional, but, if specified, it must have an absolute value in the range of 0 through 65,535. Expression 3 represents a type attribute. It is optional, but, if specified, must be a self-defining term with a value in the range of 0 through 255.

Any symbols appearing in expressions 2 and/or 3 must have been previously defined.

EXPRESSION 1 (VALUE): The assembler assigns the relocatable or absolute value of expression 1 to the symbol in the name field at assembly time. If expression 2 is omitted, the assembler also assigns a length attribute value to the symbol in the name field according to the length attribute value of the leftmost (or only) term of expression 1. The length attribute value is described in "Chapter 2. Coding and Structure." It is defined as follows:

1. If the leftmost term is a location counter reference (*), a self-defining term, or a symbol length attribute value reference, the length attribute is 1. Note that this also applies if the leftmost term is a symbol that is equated to any of these values.

2. If the leftmost term is a symbol that is used in the name field of a DC or DS instruction, the length attribute value is equal to the implicit or explicit length of the first (or only) constant specified in the DC or DS operand field.

3. If the leftmost term is a symbol that is used in the name field of a machine instruction, the length attribute value is equal to the length of the assembled instruction.

4. Symbols that name assembler instructions, except the DC and DS instructions, have a length attribute value of 1. However, the name of a CCW, CCW0, or CCW1 instruction has a length attribute value of 8.

5. The length attribute value assigned in cases 2 to 4 above only applies to the assembly-time value of the attribute. Its value at preassembly time, during conditional assembly processing, is always 1.

6. Further, if expression 3 is omitted, the assembler assigns a type attribute value of U to the symbol in the name field.

EXPRESSION 2 (LENGTH-ATTRIBUTE VALUE): If expression 2 is specified, the assembler assigns its value as a length attribute value to the symbol in the name field. This value overrides the normal length attribute value implicitly assigned from expression 1. If expression 2 is a self-defining term, the assembler also assigns the length attribute value to the symbol at preassembly time (during conditional assembly processing).

Note: This expression must have been previously defined.

EXPRESSION 3 (TYPE-ATTRIBUTE VALUE): If expression 3 is specified, it must be a self-defining term. The assembler assigns its EBCDIC value as a type attribute value to the symbol in the name field. This value overrides the normal type attribute value implicitly assigned from expression 1.

Using Preassembly Values: You can use the preassembly values assigned by the assembler in conditional assembly processing.

If only expression 1 is specified, the assembler assigns a preassembly value of 1 to the length attribute, and a preassembly value of U to the type attribute of the symbol. These values can be used in conditional assembly (although references to the length attribute of the symbol will be flagged). The absolute or relocatable value of the symbol, however, is not assigned until assembly, and thus may not be used at preassembly.

If you include expressions 2 and 3 and wish to use the explicit attribute values in preassembly processing, then

1. The symbol in the name field must be an ordinary symbol.
2. Expression 2 and expression 3 must be single self-defining terms.

SYMBOL IN THE NAME FIELD: The assembler assigns an absolute or relocatable value, a length attribute value, and a type attribute value to the symbol in the name field.

The absolute or relocatable value of the symbol is assigned at assembly time, and is, therefore, not available for conditional assembly processing at preassembly time.

The type and length attribute values of the symbol are available for conditional assembly processing under the following conditions:

- The symbol in the name field must be an ordinary symbol.
- Expression 2 and expression 3 must be single self-defining terms.

REDEFINING SYMBOLIC OPERATION CODES

OPSYN—EQUATE OPERATION CODE

The OPSYN instruction allows you to define your own set of symbols to represent operation codes for:

- Machine and extended mnemonic branch instructions
- Assembler instructions, including conditional assembly instructions

You can also prevent the assembler from recognizing a symbol that represents a current operation code.

The OPSYN instruction has two formats:

Name	Operation	Operand
Any symbol or operation code	OPSYN	An operation code

or

Name	Operation	Operand
An operation code	OPSYN	Blank

The OPSYN instruction can be coded anywhere in the program to redefine an operation code.

The operation code specified in the name field or the operand field must represent either:

1. The operation code of one of the assembler or machine instructions as described in "Chapter 3. Addressing, Program Sectioning, and Linking" on page 40, "Chapter 4. Machine Instruction Statements,"

"Chapter 5. Assembler Instruction Statements," or"Chapter 9. How to Write Conditional Assembly Instructions" on page 195, respectively, or

2. The operation code defined by a previous OPSYN instruction.

The OPSYN instruction assigns the properties of the operation code specified in the operand field to the symbol in the name field. A blank in the operand field causes the operation code in the name field to lose its properties as an operation code.

Examples:

1. The symbol in the name field can represent a valid operation code. It loses its current properties as if it had been defined in an OPSYN instruction with a blank operand field. In the following example, L and LR will both possess the properties of the LR machine instruction operation code:

```
L OPSYN LR
```

2. When the same symbol appears in the name field of two OPSYN instructions, the latest definition takes precedence. In the example below, STORE now represents the STH machine operation:

```
STORE OPSYN ST
STORE OPSYN STH
```

REDEFINING CONDITIONAL ASSEMBLY INSTRUCTIONS: A redefinition of a conditional assembly operation code will have an effect only on macro definitions appearing after the OPSYN instruction. Thus, the new definition is not valid during the processing of subsequent macro instructions calling a macro that was defined prior to the OPSYN statement.

Any OPSYN statement redefining the operation code of an instruction generated from a macro instruction will, however, be valid, even if the definition of the macro was made prior to the OPSYN statement. The following example illustrates this difference between conditional assembly instructions and model statements within macro instructions.

```
Name    Operation  Operand  Remark

        MACRO               macro header
        MAC        ...      macro prototype
        AIF        ...
        MVC        ...
        MEND                macro trailer
        .
AIF     OPSYN      AGO      assign AGO properties to AIF
MVC     OPSYN      MVI      assign MVI properties to MVC
        .
        MAC        ...      macro call
        [AIF       ...      evaluatad as AIF instruction;
                            generated AIFs not printed]
        MVC        ...      evaluated as MVI instruction
        .
        .                   open code started at this point
        AIF        ...      evaluated as AGO instruction
        MVC        ...      evaluated as MVI instruction
```

AIF and MVC instructions are used in a macro definition. OPSYN instructions are used to assign the properties of AGO to AIF and to assign the properties of MVI to MVC, after the macro definition has been edited. In subsequent calls to that macro, AIF is still defined as an AIF operation, while MVC is treated as an MVI operation. In open code following the OPSYN instructions, the operations of both instructions are derived from their new definitions. If the macro is redefined, either by means of a loop to a point before the macro definition or by a subsequent macro definition defining the same macro, the new

definitions of AIF and MVC (that is, AGO and MVI) will be fixed for future expansions.

DATA DEFINITION INSTRUCTIONS

The data definition instruction statements are: Define Constant (DC), Define Storage (DS), and three types of Channel Command Words (CCW, CCW0, and CCW1).

These statements are used to define constants, reserve storage, and specify the contents of channel command words, respectively. You can also provide a label for these instructions and then refer to the data symbolically in the operands of machine and assembler instructions. This data is generated and storage is reserved at assembly time, and used by the machine instructions at execution time.

DC—DEFINE CONSTANT

You specify the DC instruction to define the data constants you need for program execution. The DC instruction causes the assembler to generate the binary representation of the data constant you specify into a particular location in the assembled source module; this is done at assembly time.

Types of Constants

The DC instruction can generate the following types of constants:

Binary constants — to define bit patterns.

```
For example: FLAG    DC  B'0001000'
```

Character constants — to define character strings or messages.

```
For example: CHAR    DC  C'string of characters'
```

Hexadecimal constants — to define large bit patterns.

```
For example: PATTERN  DC  X'FF00FF00'
```

Fixed-point constants — for use by the fixed-point and other instructions of the universal set.

```
For example:        L   3,FCON
            FCON    DC  F'100'
```

Decimal constants — for use by the decimal instructions.

```
For example:        AP  AREA,PCON
            PCON    DC  P'100'
            AREA    DS  P
```

Floating-point constants — for use by the floating-point instructions.

```
For example:        LE  2,ECON
            ECON    DC  E'100.50'
```

Address constants — to define addresses mainly for the use of the fixed-point and other instructions in the universal instruction set.

```
For example:        L   5,ADCON
            ADCON   DC  A(SOMWHERE)
```

Format of DC Instruction

The format of the DC instruction statement is as follows:

Name	Operation	Operand
Any symbol or blank	DC	One or more operands separated by commas

The symbol in the name field represents the address of the first byte of the assembled constant. If several operands are specified, the first constant defined is addressable by the symbol in the name field. The other constants can be reached by relative addressing.

Each operand in a DC instruction consists of four subfields: the first three describe the constant; the fourth provides the nominal value(s) for the constant(s) to be generated. The subfields of each DC operand are written in the following sequence:

```
    1          2        3          4
Duplication   Type   Modifiers   Nominal
Factor                           Value(s)
```

For example:

```
  10XL2'FA'
```

The four subfields are:

1. Duplication factor, such as "10"
2. Type, such as "X"
3. Modifiers, such as "L2"
4. Nominal value(s), such as "FA"

If all subfields are specified, the order given above is required. The first and third subfields can be omitted, but the second and fourth must be specified in that order.

Rules for DC Operand

1. The type subfield and the nominal value must always be specified.
2. The duplication factor and modifier subfields are optional.
3. When multiple operands are specified, they can be of different types.
4. When multiple nominal values are specified in the fourth subfield, they must be separated by commas and be of the same type. Multiple nominal values are not allowed for character constants.
5. The descriptive subfields apply to all the nominal values.

   Note: Separate constants are generated for each separate operand and nominal value specified.

6. No blanks are allowed:

   a. Between subfields.

   b. Between multiple operands.

   c. Within any subfields, unless they occur as part of the nominal value of a character constant, or as part of a

character self-defining term in a modifier expression, or in the duplication factor subfield.

Information about Constants

SYMBOLIC ADDRESSES OF CONSTANTS: Constants defined by the DC instruction are assembled into an object module at the location at which the instruction is specified. However, the type of constant being defined will determine whether the constant is to be aligned on a particular storage boundary or not (see "Alignment of Constants" below). The value of the symbol that names the DC instruction is the address of the leftmost byte (after alignment) of the first or only constant.

LENGTH ATTRIBUTE VALUE OF SYMBOLS NAMING CONSTANTS: The length attribute value assigned to the symbols in the name field of the constants is equal to:

- The implicit length (see (1) in Figure 19 on page 93) of the constant when no explicit length is specified in the operand of the constant, or
- The explicitly specified length (see (2) in Figure 19) of the constant.

Note: If more than one operand is present, the length attribute value of the symbol is the length in bytes of the first constant specified, according to its implicitly or explicitly specified length.

ALIGNMENT OF CONSTANTS: The assembler aligns constants on different boundaries according to the following:

- On boundaries implicit to the type of constant (see (1) in Figure 20 on page 94) when no length specification is supplied.
- On byte boundaries (see (2) in Figure 20) when an explicit length specification is made.

Bytes that are skipped to align a constant at the proper boundary are not considered part of the constant. They are filled with zeros.

Notes:

1. The automatic alignment of constants and areas does not occur if the NOALIGN assembler option has been specified when the assembler was invoked.
2. Alignment can be forced to any boundary by a preceding DS (or DC) instruction with a zero duplication factor. This occurs when either the ALIGN or NOALIGN option is set.

Type of constant	Implicit Length[1]	Examples	Value of Length Attribute[2]
B	as needed	DC B'10010000'	1
C	as needed	DC C'WOW'	3
		DC CL8'WOW'	8
X	as needed	DC X'FFEE00'	3
		DC XL2'FFEE'	2
H	2	DC H'32'	2
F	4	DC FL3'32'	3
P	as needed	DC P'123'	2
		DC PL4'123'	4
Z	as needed	DC Z'123'	3
		DC ZL10'123'	10
E	4		
D	8		
L	16		
Y	2	DC Y(HERE)	2
A	4	DC AL1(THERE)	1
S	2		
V	4		
Q	4		

[1] Depends on type

[2] Depends on whether or not an explicit length is specified in constant

Figure 19. Length Attribute Value of Symbols Naming Constants

Padding and Truncation of Values

The nominal values specified for constants are assembled into storage. The amount of space available for the nominal value of a constant is determined:

- By the explicit length specified in the second operand subfield, or
- If no explicit length is specified, by the implicit length according to the type of constant defined (see Appendix C, "Summary of Constants" on page 250).

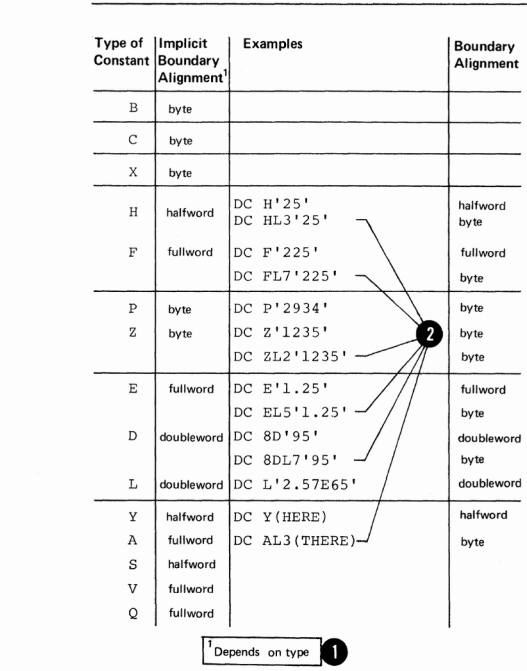


Figure 20. Alignment of Constants

PADDING: If more space is available than is needed to accommodate the binary representation of the nominal value, the extra space is padded:

- With binary zeros on the left for the binary (B), hexadecimal (X), fixed-point (H,F), packed decimal (P), and all address (A,Y,S,V,Q) constants

- With EBCDIC zeros on the left (X'F0') for the zoned decimal (Z) constants
- With EBCDIC blanks on the right (X'40') for the character (C) constants

Notes:

1. Floating-point constants (E,D,L) are also padded on the right with zeros.
2. Padding is on left for all constants except the character constant.
3. Padding is on the right for character constant.

TRUNCATION: If less space is available than is needed to accommodate the nominal value, the nominal value is truncated and part of the constant is lost. Truncation of the nominal value is:

- On the left for the binary (B), hexadecimal (X), decimal (P and Z), and address (A and Y) constants
- On the right for the character (C) constant

However, the fixed-point constants (H and F) will not be truncated but flagged if significant bits would be lost through truncation.

Notes:

1. Floating-point constants (E,D,L) are not truncated; they are rounded.
2. The above rules for padding and truncation also apply when the bit-length specification is used (see "Subfield 3: Modifiers" below).

Subfield 1: Duplication Factor

The duplication factor may be omitted. If specified, it causes the nominal value or multiple nominal values specified in a constant to be generated the number of times indicated by the factor. It is applied after the nominal value or values are assembled into the constant. Symbols used in subfield 1 need not be previously defined. This does not apply to literals.

The factor can be specified by an unsigned decimal self-defining term or by an absolute expression enclosed in parentheses.

The expression should have a positive value or be equal to zero.

Notes:

1. The value of a location counter reference in a duplication factor is the value before any alignment to boundaries is done, according to the type of constant specified.
2. A duplication factor of zero is permitted with the following results:
   a. No value is assembled.
   b. Alignment is forced according to the type of constant specified, if no length attribute is present (see "Alignment of Constants" above).
   c. The length attribute of the symbol naming the constant is established according to the implicitly or explicitly specified length.

3. If duplication is specified for an address constant containing a location counter reference, the value of the location counter reference is incremented by the length of the constant before each duplication is performed (for examples, see "Address Constants—A and Y" on page 112.

Subfield 2: Type

The type subfield must be specified. From the type specification, the assembler determines how it is to interpret the constant and translate it into the appropriate machine format. The type is specified by a single-letter code as shown in Figure 21.

Further information about these constants is provided in the discussion of the constants themselves under "Subfield 4: Nominal Value" on page 100.

Code	Types of Constant	Machine Format
C	Character	8-bit code for each character
X	Hexadecimal	4-bit code for each hexadecimal digit
B	Binary	Binary format
F	Fixed-point	Signed, fixed-point binary format; normally a fullword
H	Fixed-point	Signed, fixed-point binary format; normally a halfword
E	Floating-point	Short floating-point format; normally a fullword
D	Floating-point	Long floating-point format; normally a doubleword
L	Floating-point	Extended floating-point format; normally two doublewords
P	Decimal	Packed decimal format
Z	Decimal	Zoned decimal format
A	Address	Value of address; normally a fullword
Y	Address	Value of address; normally a halfword
S	Address	Base register and displacement value; a halfword
V	Address	Space reserved for external symbol addresses; each address normally a fullword
Q	Address	Space reserved for external dummy section offset

Figure 21. Type Codes for Constants

The type specification indicates to the assembler:

1. How the nominal value(s) specified in subfield 4 is to be assembled; that is, which binary representation or machine format the object code of the constant must have.
2. At what boundary the assembler aligns the constant, if no length specification is present.
3. How much storage the constant is to occupy, according to the implicit length of the constant, if no explicit length specification is present (for details, see "Padding and Truncation of Values" on page 93).

Subfield 3: Modifiers

Modifiers describe the length in bytes desired for a constant (in contrast to an implied length), and the scaling and exponent for the constant.

The three modifiers are:

1. The length modifier (L), which explicitly defines the length in bytes desired for a constant. For example:

```
LENGTH  DC  XL10'FF'
```

2. The scale modifer (S), which is only used with the fixed-point or floating-point constants (for details, see below under "Scale Modifier"). For example:

```
SCALE  DC  FS8'35.92'
```

3. The exponent modifier (E), that is only used with fixed-point or floating-point constants, and which indicates the power of 10 by which the constant is to be multiplied before conversion to its internal binary format. For example:

```
EXPON  DC  EE3'3.414'
```

If multiple modifiers are used, they must appear in this sequence: length, scale, exponent. For example:

```
ALL3  DC  DL7S3E50'2.7182'
```

Symbols used in subfield 3 need not be previously defined. This does not apply to literals.

LENGTH MODIFIER: The length modifier indicates the number of bytes of storage into which the constant is to be assembled. It is written as Ln, where n is either a decimal self-defining term or an absolute expression enclosed by parentheses. It must have a positive value, and any symbols it contains must be previously defined.

When the length modifier is specified:

- Its value determines the number of bytes of storage allocated to a constant. It, therefore, determines whether the nominal value of a constant must be padded or truncated to fit into the space allocated (see "Padding and Truncation of Values" on page 93).
- No boundary alignment, according to constant type, is provided (see "Alignment of Constants" above).
- Its value must not exceed the maximum length allowed for the various types of constant defined.

Note: For character constants, when no length is specified, the whole constant is assembled into its implicit length.

Bit-Length Specification: The length modifier can be specified to indicate the number of bits into which a constant is to be assembled. The bit-length specification is written as Ln, where n is either a decimal self-defining term, or an absolute expression enclosed in parentheses. It must have a positive value. Symbols that it contains need not be previously defined.

The value of n must lie between 1 and the number of bits (a multiple of 8) that are required to make up the maximum number of bytes allowed in the type of constant being defined. The bit-length specification cannot be used with the S-, V-, and Q-type constants.

When only one operand and one nominal value are specified in a DC instruction, the following rules apply:

1. The bit-length specification allocates a field into which a constant is to be assembled. The field starts at a byte boundary and can run over one or more byte boundaries, if the bit length specified is greater than 8.

   If the field does not end at a byte boundary and if the bit length specified is not a multiple of 8, the remainder of the last byte is filled with zeros.

2. The nominal value of the constant is assembled into the field:

a. Starting at the high order end for the C-, E-, D-, and L-type constants

b. Starting at the low-order end for the remaining types of constants that allow bit-length specification

3. The nominal value is padded or truncated to fit the field (see "Padding and Truncation of Values" on page 93).

   Padding of character constants is done with hexadecimal blanks, X'40'; other constant types are padded with zeros.

Note: The length attribute value of the symbol naming a DC instruction with a specified bit length is equal to the minimum number of integral bytes needed to contain the bit length specified for the constant. L'TRUNCF is equal to 2. Thus, a reference to TRUNCF would address the entire two bytes that are assembled.

When more than one operand is specified in a DC instruction, or more than one nominal value in a DC operand, the above rules about bit-length specifications also apply, except:

1. The first field allocated starts at a byte boundary, but the succeeding fields start at the next available bit.

2. After all the constants have been assembled into their respective fields, the bits remaining to make up the last byte are filled with zeros.

   Note: If duplication is specified, filling with zeros occurs once at the end of all the fields occupied by the duplicated constants.

3. The length attribute value of the symbol naming the DC instruction is equal to the number of integral bytes that would be needed to contain the bit length specified for the first constant to be assembled.

Storage Requirement for Constants: The total amount of storage required to assemble a DC instruction is the sum of:

1. The requirements for the individual DC operands specified in the instruction. The requirement of a DC operand is the product of:

   a. The length (implicit or explicit)

   b. The number of nominal values

   c. The duplication factor, if specified

2. The number of bytes skipped for the boundary alignment between different operands.

SCALE MODIFIER: The scale modifier specifies the amount of internal scaling that is desired:

- Binary digits for fixed-point constants (H, F)
- Hexadecimal digits for floating-point constants (E, D, L)

The scale modifier can be used only with the above types of constant.

The allowable range for each type of constant is as follows:

Fixed-point constants H and F	-187 through +346
Floating-point constants E and D	0 through 14
Floating-point constant L	0 through 28

The scale modifier is written as Sn, where n is either a decimal self-defining term, or an absolute expression enclosed in parentheses.

Both types of specification can be preceded by a sign; if no sign is present, a plus sign is assumed.

Scale Modifier for Fixed-Point Constants: The scale modifier for fixed-point constants specifies the power of two by which the fixed-point constant must be multiplied after its nominal value has been converted to its binary representation, but before it is assembled in its final "scaled" form. Scaling causes the binary point to move from its assumed fixed position at the right of the rightmost bit position.

Notes:

1. When the scale modifier has a positive value, it indicates the number of binary positions to be occupied by the fractional portion of the binary number.

2. When the scale modifier has a negative value, it indicates the number of binary positions to be deleted from the integer portion of the binary number.

3. When positions are lost because of scaling (or lack of scaling), rounding occurs in the leftmost bit of the lost portion. The rounding is reflected in the rightmost position saved.

Scale Modifier for Floating-Point Constants: The scale modifier for floating-point constants must have a positive value. It specifies the number of hexadecimal positions that the fractional portion of the binary representation of a floating-point constant is to be shifted to the right. The hexadecimal point is assumed to be fixed at the left of the leftmost position in the fractional field. When scaling is specified, it causes an unnormalized hexadecimal fraction to be assembled (unnormalized is when the leftmost positions of the fraction contain hexadecimal zeros). The magnitude of the constant is retained, because the exponent in the characteristic portion of the constant is adjusted upward accordingly. When hexadecimal positions are lost, rounding occurs in the leftmost hexadecimal position of the lost portion. The rounding is reflected in the rightmost position saved.

EXPONENT MODIFIER: The exponent modifier specifies the power of 10 by which the nominal value of a constant is to be multiplied before it is converted to its internal binary representation. It can only be used with the fixed-point (H and F) and floating-point (E, D, and L) constants. The exponent modifier is written as En, where n can be either a decimal self-defining term, or an absolute expression enclosed in parentheses.

The decimal self-defining term or the expression can be preceded by a sign: If no sign is present, a plus sign is assumed. The range for the exponent modifier is -85 through +75.

Notes:

1. The exponent modifier is not to be confused with the exponent that can be specified in the nominal value subfield of fixed-point and floating-point constants.

   The exponent modifier affects each nominal value specified in the operand, whereas the exponent written as part of the nominal value subfield only affects the nominal value it follows. If both types of exponent specification are present in a DC operand, their values are algebraically added together before the nominal value is converted to binary form. However, this sum must lie within the permissible range of -85 through +75.

2. The value of the constant, after any exponents have been applied, must be contained in the implicitly or explicitly specified length of the constant to be assembled.

Subfield 4: Nominal Value

The nominal value subfield must always be specified. It defines the value of the constant (or constants) described and affected by the subfields that precede it. It is this value that is assembled into the internal binary representation of the constant. The formats for specifying constants are described as follows:

Constant Type	Single Nominal Value	Multiple Nominal Value
C	'value'	not allowed
B X H F P Z E D L	'value'	'value,value,...value'
A Y S Q V	(value)	(value,value,...value)

As the above list shows, a data constant value (any type except A, Y, S, Q, and V) is enclosed by apostrophes. An address constant value (type A, Y, S, Q, or V) is enclosed by parentheses. To specify two or more values in the subfield, the values must be separated by commas, and the entire sequence of values must be enclosed by the appropriate delimiters; that is, apostrophes or parentheses. Multiple values are not permitted for character constants.

How nominal values are specified and interpreted by the assembler is explained in each of the following subsections, starting with "Binary Constant—B" below.

LITERAL CONSTANTS: Literal constants allow you to define and refer to data directly in machine instruction operands. You do not need to define a constant separately in another part of your source module. The diffference between a literal, a data constant, and a self-defining term is described in "Literals" on page 32.

A literal constant is specified in the same way as the operand of a DC instruction. The general rules for the operand subfields of a DC instruction also apply to the subfield of a literal constant. Moreover, the rules that apply to the individual types of constants apply to literal constants as well.

However, literal constants differ from DC operands in the following ways:

- Literals must be preceded by an equal sign.
- Multiple operands are not allowed.
- The duplication factor must not be zero.

The following text describes each of the constant types and provides examples. The constant types are:

- Binary
- Character
- Hexadecimal
- Fixed-Point
- Decimal
- Packed Decimal
- Zoned Decimal
- Address
- Floating-Point

BINARY CONSTANT—B: The binary constant allows you to specify the precise bit pattern you want assembled into storage. Each binary constant is assembled into the integral number of bytes (see (1) in Figure 22 on page 102) required to contain the bits specified.

The following example shows the coding used to designate a binary constant. BCON would have a length attribute of 1.

Name	Operation	Operand
BCON	DC	B'11011101'
BTRUNC	DC	BL1'100100011'
BPAD	DC	BL1'101'

BTRUNC would assemble with the leftmost bit truncated, as follows:

```
00100011
```

BPAD would assemble with five zeros as padding, as follows:

```
00000101
```

Subfield	Binary Constants 3. Constant Type Binary (B)		
1. Duplication Factor allowed	Yes		
2. Modifiers Implicit Length: (Length Modifier not present)	As needed B DC B'10101111' C DC B'101'	L'B = 1 (1) L'C = 1	
Alignment: (Length Modifier not present)	Byte		
Range for Length:	1 through 256 (byte length) .1 through .2048 (bit length)		
Range for Scale:	Not allowed		
Range for Exponent:	Not allowed		
4. Nominal Value Represented by:	Binary digits (0 or 1)		
Enclosed by:	Apostrophes		
Exponent allowed:	No		
Number of Values per Operand:	Multiple		
Padding:	With zeros at left		
Truncation of Assembled Value:	At left		

Figure 22. Binary Constants

CHARACTER CONSTANT—C: The character constant allows you to specify character strings, such as error messages, identifiers, or other text, that the assembler will convert into their binary (EBCDIC) representation.

Any of the valid 256 punch combinations can be designated in a character constant. Each character specified in the nominal value subfield is assembled into one byte (see (1) in Figure 23 on page 104).

Multiple nominal values are not allowed, because if a comma is specified in the nominal value subfield, the assembler considers the comma a valid character (see (2) in Figure 23) and, therefore, assembles it into its binary (EBCDIC) representation. For example

```
DC  C'A,B'
```

is assembled as A,B with object code C16BC2.

Special consideration must be given to representing apostrophes and ampersands as characters. Each single apostrophe or ampersand desired as a character in the constant must be represented by a pair of apostrophes or ampersands. They are assembled as single apostrophes and ampersands (see (3) in Figure 23).

In the following example, the length attribute of FIELD is 12:

Name	Operation	Operand
FIELD	DC	C'TOTAL IS 110'

However, in this next example, the length attribute is 15, and three blanks appear in storage to the right of the zero:

Name	Operation	Operand
FIELD	DC	CL15'TOTAL IS 110'

In the next example, the length attribute of FIELD is 12, although 13 characters appear in the operand. The two ampersands count as only one byte.

Name	Operation	Operand
FIELD	DC	C'TOTAL IS &&10'

Note that, in the next example, a length of 4 has been specified, but there are five characters in the constant.

Name	Operation	Operand
FIELD	DC	3CL4'ABCDE'

The generated constant would be:

```
ABCDABCDABCD
```

On the other hand, if the length had been specified as 6 instead of 4, the generated constant would have been:

```
ABCDE ABCDE ABCDE
```

Subfield	Character Constants 3. Constant Type Character (C)		
1. Duplication Factor allowed	Yes		
2. Modifiers Implicit Length: (Length Modifier not present)	As needed `C DC C'LENGTH'` ❶	`L'C = 6`	
Alignment: (Length Modifier not present)	Byte		
Range for length:	1 through 256 (byte length) .1 through .2048 (bit length)		
Range for Scale:	Not allowed		
Range for Exponent:	Not allowed		

4. Nominal Value Represented by:	Characters (All 256 8-bit combinations)	`DC C'A''B'`
		Assembled `A'B` `A&B` ❸
		`DC C'A&&B'`
			Object Code (hex).
			C1 7D C2
			C1 50 C2

Enclosed by:	Apostrophes		
Exponent allowed:	No		
Number of values per Operand:	One	`DC C'A,B'` Assembled `A,B` ❷	C1 6B C2
Padding:	With blanks at right (X'40')		
Truncation of Assembled value:	At right		

Figure 23. Character Constants

Note that the same constant could be specified as a literal.

Name	Operation	Operand
	MVC	AREA(12),=3CL4'ABCDE'

HEXADECIMAL CONSTANT—X: You can use hexadecimal constants to generate large bit patterns more conveniently than with binary constants. Also, the hexadecimal values you specify in a source module allow you to compare them directly with the hexadecimal values generated for the object code and address locations printed in the program listing.

Each hexadecimal digit (see (1) in Figure 24 on page 106) specified in the nominal value subfield is assembled into four bits (their binary patterns can be found in "Self-Defining Terms" on page 25). See (2) in Figure 24. The implicit length in bytes of a hexadecimal constant is then half the number of hexadecimal digits specified (assuming that a hexadecimal zero is added to an odd number of digits). See (3) in Figure 24.

An 8-digit hexadecimal constant provides a convenient way to set the bit pattern of a full binary word. The constant in the following example would set the first and third bytes of a word to 1s:

Name	Operation	Operand
TEST	DS DC	0F X'FF00FF00'

The DS instruction sets the location counter to a fullword boundary. (See "DS—Define Storage" on page 123.)

The next example uses a hexadecimal constant as a literal and inserts 1s into bits 24 through 31 of register 5.

Name	Operation	Operand
	IC	5,=X'FF'

In the following example, the digit A is dropped, because 5 hexadecimal digits are specified for a length of 2 bytes:

Name	Operation	Operand
ALPHACON	DC	3XL2'A6F4E'

The resulting constant is 6F4E, which occupies the specified 2 bytes. It is duplicated three times, as requested by the duplication factor. If it had merely been specified as 3X'A6F4E', the resulting constant would have a hexadecimal zero in the leftmost position.

```
0A6F4E0A6F4E0A6F4E
```

Subfield	Hexadecimal Constants 3. Constant Type		
	Hexadecimal (X)		
1.Duplication Factor allowed	Yes		

2.Modifiers
Implicit Length: (Length Modifier not present)
	As needed
	`X DC X'FF00A2'`
	`Y DC X'F00A2'`
		`L'X = 3` ❷
		`L'Y = 3`	

Alignment: (Length Modifier not present)	Byte		
Range for Length:	1 through 256 (byte length) .1 through .2048 (bit length)		
Range for Scale:	Not allowed		
Range for Exponent:	Not allowed	❶	
4. Nominal Value Represented by:	Hexadecimal digits (0 through 9 and A through F)	`DC X'1F'` `DC X'91F'`	Object Code (hex) 0001 1111 0000 1001 0001 1111 ◄—1 byte—►
Enclosed by:	Apostrophes	❸	
Exponent allowed:	No		
Number of Values per Operand:	Multiple		
Padding:	With zeros at left		
Truncation of Assembled value:	At left		

Figure 24. Hexadecimal Constants

FIXED-POINT CONSTANT—F AND H: Fixed-point constants allow you to introduce data that is in a form suitable for the operations of the fixed-point machine instructions of the universal instruction set. The constants you define can also be automatically aligned to the proper fullword or halfword boundary for the instructions that refer to addresses on these boundaries (unless the NOALIGN option has been specified; see "Information about Constants" on page 92). You can perform algebraic functions using this type of constant because they can have positive or negative values.

A fixed-point constant is written as a decimal number, which can be followed by a decimal exponent if desired. The format of the constant is as follows:

1. The nominal value can be a signed (see (1) in Figure 25 on page 108)—plus is assumed if the number is unsigned—integer, fraction, or mixed number (see (2) Figure 25) followed by an exponent (see (3) in Figure 25): positive or negative.

2. The exponent must lie within the permissible range (see (4) in Figure 25). If an exponent modifier is also specified, the algebraic sum (see (5) in Figure 25) of the exponent and the exponent modifier must lie within the permissible range.

Some examples of the range of values that can be assembled into fixed-point constants are given below:

Length	Range of Values that can be Assembled
8	-2^{63} through $2^{63}-1$
4	-2^{31} through $2^{31}-1$
2	-2^{15} through $2^{15}-1$
1	-2^{7} through $2^{7}-1$

The range of values depends on the implicitly or explicitly specified length (if scaling is disregarded). If the value specified for a particular constant does not lie within the allowable range for a given length, the constant is not assembled, but flagged as an error.

A fixed-point constant is assembled as follows:

1. The specified number, multiplied by any exponents, is converted to a binary number.

2. Scaling is performed, if specified. If a scale modifier is not provided, the fractional portion of the number is lost.

3. The binary value is rounded, if necessary. The resulting number will not differ from the exact number specified by more than one in the least significant bit position at the right.

4. A negative number is carried in twos complement form.

5. Duplication is applied after the constant has been assembled.

A field of three fullwords is generated from the statement below. The location attribute of CONWRD is the address of the leftmost byte of the first word, and the length attribute is 4, the implied length for a fullword fixed-point constant. The expression CONWRD+4 could be used to address the second constant (second word) in the field.

Name	Operation	Operand
CONWRD	DC	3F'658474'

Subfield	Fixed-Point Constants 3. Constant Type		
	Fullword(F)	Halfword (H)	
1. Duplication Factor Allowed	Yes	Yes	
2. Modifiers Implicit Length: (Length Modifier not present)	4 bytes	2 bytes	
Alignment: (Length Modifer not present)	Full word	Half word	
Range for Length:	1 through 8 (byte length) .1 through .64 (bit length)	1 through 8 (byte length) .1 through .64 (bit length)	
Range for Scale:	– 187 through + 346	– 187 through + 346	
Range for Exponent:	– 85 through + 75 (4)	– 85 through + 75	DC HE+90'2E-88' value = $2x10^{2}$ (5)
4. Nominal Value Represented by:	Decimal digits (0 through 9) DC F'-200' (1) DC FS4'2.25' (2)	Decimal digits (0 through 9) DC H'+200' DC HS4'.25'	
Enclosed by:	Apostrophes	Apostrophes	
Exponent allowed:	Yes DC F'2E6' (3)	Yes DC H '2E-6'	
Number of Values per Operand:	Multiple	Multiple	
Padding:	With zeros at left	With zeros at left	
Truncation of Assembled value:	Not allowed	Not allowed (error message issued)	

Figure 25. Fixed-Point Constants

The next statement causes the generation of a 2-byte field containing a negative constant. Notice that scaling has been specified in order to reserve 6 bits for the fractional portion of the constant.

Name	Operation	Operand
HALFCON	DC	HS6'-25.46'

The next constant (3.50) is multiplied by 10 to the power -2 before being converted to its binary format. The scale modifier reserves 12 bits for the fractional portion.

Name	Operation	Operand
FULLCON	DC	HS12'3.50E-2'

The same constant could be specified as a literal:

Name	Operation	Operand
	AH	7,=HS12'3.50E-2'

The final example specifies three constants. Notice that the scale modifier requests 4 bits for the fractional portion of each constant. The 4 bits are provided whether or not the fraction exists.

Name	Operation	Operand
THREECON	DC	FS4'10,25.3,100'

DECIMAL CONSTANTS—P AND Z: The decimal constants allow you to introduce data in a form suitable for the operations of the decimal feature machine instructions. The packed decimal constants (P-type) are used for processing by the decimal instructions. The zoned decimal constants (Z-type) are in the form (EBCDIC representation) you can use as a print image, except for the digits in the rightmost byte.

The nominal value can be a signed (plus is assumed if the number is unsigned) decimal number. A decimal point may be written anywhere in the number, or it may be omitted. The placement of a decimal point in the definition does not affect the assembly of the constant in any way, because the decimal point is not assembled into the constant.

The specified digits are assumed to constitute an integer (see (1) in Figure 26 on page 110). You may determine proper decimal point alignment either by defining data so that the point is aligned or by selecting machine instructions that will operate on the data properly (that is, shift it for purposes of alignment).

Decimal constants are assembled as follows:

Packed Decimal Constants: Each digit is converted into its 4-bit binary equivalent (see (2) in Figure 26). The sign indicator (see (3) in Figure 26) is assembled into the rightmost four bits of the constant.

Zoned Decimal Constants: Each digit is converted into its 8-bit EBCDIC representation (see (4) in Figure 26). The sign indicator (see (5) in Figure 26) replaces the first four bits of the low-order byte of the constant.

Subfield	Decimal Constants 3. Constant Type Packed (P)	Zoned (Z)	
1. Duplication Factor Allowed	Yes	Yes	
2. Modifiers Implicit Length: (Length Modifier not present)	As needed P DC P'+593' L'P = 2	As needed Z DC Z'-593' L'Z = 3	
Alignment: (Length Modifer not present)	Byte	Byte	
Range for Length:	1 through 16 (byte length) .1 through .128 (bit length)	1 through 16 (byte length) .1 through .128 (bit length)	
Range for Scale:	Not allowed	Not allowed	
Range for Exponent:	Not allowed	Not allowed	
4. Nominal Value Represented by:	Decimal digits (0 through 9) DC P'+555' 2 → 5 5 5 C 3	Decimal digits (0 through 9) DC Z'-555' 4 → F 5 F 5 D 5 5	DC P'5.5' 0 5 5 C 1 DC P'55'
Enclosed by:	Apostrophes	Apostrophes	
Exponent allowed:	No	No	
Number of Values per Operand:	Multiple	Multiple	
Padding:	With Binary zeros at left	With EBCDIC zeros (X'F0') at left	
Truncation of Assembled value:	At left	At left	

Figure 26. Decimal Constants

The range of values that can be assembled into a decimal constant is shown below:

Type of Decimal Constant	Range of Values that can be Specified
Packed	$10^{31}-1$ through -10^{31}
Zoned	$10^{16}-1$ through -10^{16}

For both packed and zoned decimals, a plus sign is translated into the hexadecimal digit C, a minus sign into the digit D. The packed decimal constants (P-type) are used for processing by the decimal instructions.

If an even number of packed decimal digits is specified, one digit will be left unpaired because the rightmost digit is paired with the sign. Therefore, in the leftmost byte, the leftmost four bits will be set to zeros and the rightmost four bits will contain the odd (first) digit.

Examples of decimal constant definitions follow.

Name	Operation	Operand
	DC	P'+1.25'
	DC	Z'-543'
	DC	Z'79.68'
	DC	PL3'79.68'

The following statement specifies both packed and zoned decimal constants. The length modifier applies to each constant in the first operand (that is, to each packed decimal constant). Note that a literal could not specify both operands.

Name	Operation	Operand
DECIMALS	DC	PL8'+25.8,-3874, +2.3',Z'+80,-3.72'

The last example illustrates the use of a packed decimal literal.

Name	Operation	Operand
	UNPK	OUTAREA,=PL2'+25'

ADDRESS CONSTANTS: An address constant is a storage address that is translated into a constant. Address constants can be used for initializing base registers to facilitate the addressing of storage. Furthermore, they provide a means of communicating between control sections of a multisection program. However, storage addressing and control section communication are also dependent on the use of the USING assembler instruction and the loading of registers. Coding examples illustrating these considerations are provided in "How to Use the USING Instruction" in "USING—Use Base Address Register" on page 41.

An address constant, unlike other types of constants, is enclosed in parentheses. If two or more address constants are specified in an operand, they are separated by commas, and the entire sequence is enclosed by parentheses. There are five types of address constants: A, Y, S, Q, and V. A relocatable address constant may not be specified with bit lengths.

Complex Relocatable Expressions: A complex relocatable expression can only be used to specify an A- or Y-type address constant. These expressions contain two or more unpaired

relocatable terms and/or negative relocatable terms in addition to any absolute or paired relocatable terms that may be present. A complex relocatable expression might consist of external symbols and designate an address in an independent assembly that is to be linked and loaded with the assembly containing the address constant.

Address Constants—A and Y: The following sections describe how the different types of address constants are assembled from expressions that usually represent storage addresses, and how the constants are used for addressing within and between source modules.

In the A-type and Y-type address constant, you can specify any of the three types of assembly-time expressions whose values the assembler then computes and assembles into object code. You use this expression computation as follows:

- Relocatable expressions for addressing
- Absolute expressions for addressing and value computation
- Complex relocatable expressions to relate addresses in different source modules

Notes:

1. No bit-length specification (see (1) in Figure 27 on page 113) is allowed when a relocatable or complex relocatable expression (see (2) in Figure 27) is specified. The only explicit lengths that can be specified with these addresses are:

   a. 3 or 4 bytes for A-type constants

   b. 2 bytes for Y-type constants

2. The value of the location counter reference (*) when specified in an address constant varies from constant to constant, if any of the following, or a combination of the following, are specified:

   a. Multiple operands

   b. Multiple nominal values (see (3) in Figure 27)

   c. A duplication factor (see (4) in Figure 27)

   The location counter is incremented with the length of the previously assembled constant.

3. When the location counter reference occurs in a literal address constant, the value of the location counter is the address of the first byte of the instruction.

CAUTION: Specification of Y-type address constants with relocatable expressions should be avoided in programs that are to be executed on machines having more than 32,767 bytes of storage capacity. In any case, Y-type relocatable address constants should not be used in programs to be executed under IBM System/370 control.

The A-type and Y-type address constants are processed as follows: If the nominal value is an absolute expression, it is computed to its 32-bit value and then truncated on the left to fit the implicit or explicit length of the constant. If the nominal value is a relocatable or complex relocatable expression, it is not completely evaluated until linkage edit time when the object modules are transformed into load modules. The 24-bit (or smaller) relocated address values are then placed in the fields set aside for them at assembly time by the A-type and Y-type constants.

Subfield	Address Constants (A and Y)		
	3. Constant Type		
	A – Type	Y – Type	4
1. Duplication Factor allowed	Yes	Yes Object Code in Hex ⟶	A DC 5AL1(*-A) 0001020304
2. Modifiers Implicit Length: (Length Modifer not present)	4 bytes	2 bytes	
Alignment: (Length Modifier not present)	Full word	Half word	
Range for Length:	1 through 4 (byte length) .1 through .32 (bit length) 1	1 through 2 (byte length) .1 through .16 (bit length)	
Range for Scale:	Not allowed	Not allowed	
Range for Exponent:	Not allowed	Not allowed	
4. Nominal Value Represented by:	Absolute, relocatable, or complex relocatable expressions 2 DC A(ABSOL+10)	Absolute, relocatable, or complex relocatable expressions DC Y(RELOC+32)	3 A DC Y(*-A,*+4) [redacted] values
Enclosed by:	Parentheses	Parentheses	
Exponent allowed:	No	No	
Number of Values per Operand:	Multiple	Multiple	
Padding:	With zeros at left	With zeros at left	
Truncation of Assembled value:	At left	At left	

Figure 27. A and Y Address Constants

In the following examples, the field generated from the statement named ACON contains four constants, each of which occupies four bytes. Note that there is a location counter reference in one. The value of the location counter will be the address of the first byte allocated to the fourth constant. The second statement shows the same set of constants specified as literals (that is, address constant literals).

Name	Operation	Operand
ACON	DC	A(108,LOP,END-STRT, *+4096)
	LM	4,7,=A(108,LOP,END-STRT, *+4096)

Note: When the location counter reference occurs in a literal, as in the LM instruction above, the value of the location counter is the address of the first byte of the instruction.

Address Constant—S: You can use the S-type address constant to assemble an explicit address; that is, an address in base-displacement form. You can specify the explicit address yourself or allow the assembler to compute it from an implicit address, using the current base register and address in its computation.

The nominal values can be specified in two ways:

1. As one absolute or relocatable expression (see (1) in Figure 28 on page 115) representing an implicit address

2. As two absolute expressions (see (2) in Figure 28) the first of which represents the displacement (see (3) in Figure 28), and the second, the base register (see (4) in Figure 28).

The address value represented by the expression in 1 in Figure 28, will be converted by the assembler into the proper base register and displacement value. An S-type constant is assembled as a halfword and aligned on a halfword boundary. The leftmost four bits of the assembled constant represent the base register designation; the remaining 12 bits, the displacement value.

If length specification is used, only 2 bytes may be specified. S-type address constants may not be specified as literals.

Address Constant—V: The V-type constant allows you to reserve storage for the address of a location in a control section that lies in another source module. You should use the V-type address constant only to branch to the external address specified. This use is contrasted with another method; that is, of specifying an external symbol, identified by an EXTRN instruction, in an A-type address constant.

Because you specify a symbol in a V-type address constant, the assembler assumes that it is an external symbol. A value of zero is assembled into the space reserved for the V-type constant; the correct relocated value of the address is inserted into this space by the linkage editor before your object program is loaded.

The symbol specified (see (1) in Figure 29 on page 116) in the nominal value subfield does not constitute a definition of the symbol for the source module in which the V-type address constant appears.

The symbol specified in a V-type constant must not represent external data in an overlay program.

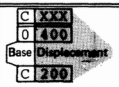
Subfield	Address Constants (S)		
	3. Constant Type		
	S – Type		
1. Duplication Factor Allowed	Yes		
2. Modifiers Implicit Length: (Length Modifier not present)	2 bytes		
Alignment: (Length Modifier not present)	Half word		
Range for length: (in bytes)	2 only (no bit length)		
Range for Scale:	Not allowed		
Range for Exponent:	Not allowed		
4. Nominal Value Represented by:	Absolute or relocatable expression ❶ Two absolute expressions ❷	DC S(RELOC) DC S(1024) ❸ ❹ DC S(512(12))	
Enclosed by:	Parentheses		
Exponent allowed:	No		
Number of Values per operand :	Multiple		
Padding:	Not applicable		
Truncation of Assembled value:	Not applicable		

Figure 28. S Address Constants

Subfield	Address Constants (V)	
	3. Constant Type	
	V – Type	
1. Duplication Factor allowed	Yes	
2. Modifiers		
Implicit l ength: (Length Modifier not present)	4 bytes	
Alignment: (Length Modifier not present)	Full word	
Range for Length: (in bytes)	4 or 3 only (no bit length)	
Range for Scale:	Not allowed	
Range for Exponent:	Not allowed	
4. Nominal Value Represented by:	A single relocatable symbol	DC V(MODA) (1) DC V(EXTADR)
Enclosed by:	Parentheses	
Exponent allowed:	No	
Number of values per Operand:	Multiple	
Padding:	With zeros at left	
Truncation of assembled value:	Not applicable	

Figure 29. V Address Constants

In the following example, 12 bytes will be reserved, because there are three symbols. The value of each assembled constant will be zero until the program is loaded. It must be emphasized that a V-type address constant of length less than 4 can and will be processed by the assembler, but cannot be handled by the linkage editor.

Name	Operation	Operand
VCONST	DC	V(SORT,MERGE,CALC)

Address Constant—Q: You use this constant to reserve storage for the offset into a storage area of an external dummy section. The offset is entered into this space by the linkage editor. When the offset is added to the address of an overall block of storage set aside for external dummy sections, it allows you to address the desired section.

For a description of the use of the Q-type address constant in combination with an external dummy section, see "External Dummy Sections" on page 62. See also Figure 30 on page 118 for details.

In the following example, to access VALUE, the value of A is added to the base address of the block of storage allocated for external dummy sections. Q-type address constants may not be specified in literals.

Name	Operation	Operand
A	DC	Q(VALUE)

Note: The DXD or DSECT names referenced in the Q-type address constant need not be previously defined.

Subfield	Address Constants (Q)	
	3. Constant Type	
	Q-Type	
1. Duplication Factor allowed	Yes	
2. Modifiers Implicit Length: (Length Modifier not present)	4 bytes	
Alignment: (Length Modifier not present)	Fullword	
Range for Length: (in bytes)	1-4 bytes (no bit length)	
Range for Scale:	Not allowed	
Range for Exponent:	Not allowed	
4. Nominal Value Represented by	A single relocatable symbol	DC Q(DUMMYEXT) DC Q(DXDEXT)
Enclosed by:	Parentheses	
Exponent allowed:	No	
Number of Values per Operand:	Multiple	
Padding:	With zeros at left	
Truncation of Assembled Value	At left	

Figure 30. Q Address Constants

FLOATING-POINT CONSTANTS—E, D, AND L: Floating-point constants allow you to introduce data that is in the form suitable for the operations of the floating-point feature instructions. These constants have the following advantages over fixed-point constants.

- You do not have to consider the fractional portion of a value you specify, nor worry about the position of the decimal point when algebraic operations are to be performed.
- You can specify both much larger and much smaller values.
- You retain greater processing precision; that is, your values are carried in more significant figures.

The nominal value can be a signed (see (1) in Figure 31 on page 120)—plus is assumed if the number is unsigned—integer, fraction, or mixed number (see (2) in Figure 31) followed by an exponent (positive or negative). The exponent (see (3) in Figure 31) must lie within the permissible range. If an exponent modifier is also specified, the algebraic sum of the exponent and the exponent modifier must lie within the permissible range.

The format of the constant is shown in Figure 32.

The value of the constant is represented by two parts:

1. An exponent portion (see (1) in Figure 32 on page 121), followed by
2. A fractional portion (see (2) in Figure 32).

A sign bit (see (3) in Figure 32) indicates whether a positive or negative number has been specified. The number specified must first be converted into a hexadecimal fraction before it can be assembled into the proper internal format. The quantity expressed is the product of the fraction (see (4) in Figure 32) and the number 16 raised to a power (see (5) in Figure 32). Figure 32 shows the external format of the three types of floating-point constants.

The range of values that can be assembled into floating-point constants is given below:

Type of Constant	Range of Magnitude (M) of Values (Positive and Negative)
E	$16^{-65} \leq M \leq (1-16^{-6}) \times 16^{63}$
D	$16^{-65} \leq M \leq (1-16^{-14}) \times 16^{63}$
L	$16^{-65} \leq M \leq (1-16^{-28}) \times 16^{63}$
	Approximately:
E,D,L	$5.4 \times 10^{-79} \leq M \leq 7.2 \times 10^{75}$

If the value specified for a particular constant does not lie within these ranges, the constant is not assembled, but is flagged as an error.

Subfield	Floating Point Constants 3. Constant Type		
	SHORT (E)	**LONG (D)**	**EXTENDED (L)**
1. Duplication Factor Allowed	Yes	Yes	Yes
2. Modifiers Implicit Length: (Length Modifier Not Precent)	4 Bytes	8 Bytes	16 Bytes
Alignment: (Length Modifier Not Present)	Full Word	Double Word	Double Word
Range for Length:	1 through 8 (byte length) .1 through .64 (bit length)	1 through 8 (byte length) .1 through .64 (bit length)	1 through 16 (byte length) .1 through .128 (bit length)
Range for Scale:	0 through 14	0 through 14	0 through 28
Range for Exponent:	– 85 through + 75	– 85 through + 75	– 85 through + 75
4. Nominal Value Represented by:	Decimal Digits (0 through 9) DC E'+525' (1) DC E'5.25' (2)	Decimal Digits (0 through 9) DC D'-525' (1) DC D'+.001' (2)	Decimal Digits (0 through 9) DC L'525' DC L'3.414' (2)
Enclosed by:	Apostrophes	Apostrophes	Apostrophes
Exponent Allowed:	Yes DC E'1E+60' (3)	Yes DC D'-2.5E10' (3)	Yes (3) DC L'3.712E-3'
Number of Values per Operand:	Multiple	Multiple	Multiple
Padding:	With hexadecimal zeros at right	With hexadecimal zeros at right	With hexadecimal zeros at right
Truncation of Assembled Value:	Not applicable (Values are rounded)	Not Applicable (Values are Rounded)	Not applicable (Values are Rounded)

Figure 31. Floating-Point Constants

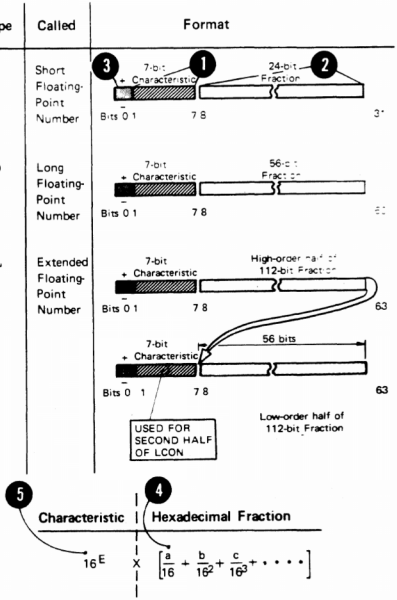


Figure 32. Floating-Point External Formats

Binary Representation: The assembler assembles a floating-point constant into its binary representation as follows: The specified number, multiplied by any exponents, is converted to the required two-part format. The value is translated into:

- A fractional portion represented by hexadecimal digits and the sign indicator. The fraction is then entered into the leftmost part of the fraction field of the constant (after rounding).

- An exponent portion represented by the excess 64 binary notation, which is then entered into the characteristic field of the constant.

The excess 64 binary notation is when the value of the characteristic between +127 and +64 represents the exponents of 16 between +63 and 0 (by subtracting 64), and the value of the characteristic between +63 and 0 represents the exponents of 16 between -1 and -64.

Notes:

1. The L-type floating-point constant resembles two contiguous D-type constants. The sign of the second doubleword is assumed to be the same as the sign of the first.

   The characteristic for the second doubleword is equal to the characteristic for the first minus 14 (the number of hexadecimal digits in the fractional portion of the first doubleword).

2. If scaling has been specified, hexadecimal zeros are added to the left of the normalized fraction (causing it to become unnormalized), and the exponent in the characteristic field is adjusted accordingly. (For further details on scaling, see "Subfield 3: Modifiers" on page 96.)

3. Rounding of the fraction is performed according to the implied or explicit length of the constant. The resulting number will not differ from the exact value specified by more than one in the last place.

4. Negative fractions are carried in true representation, not in the twos complement form.

5. Duplication is applied after the constant has been assembled.

6. An implied length of 4 bytes is assumed for a short (E) constant and 8 bytes for a long (D) constant. An implied length of 16 bytes is assumed for an extended (L) constant. The constant is aligned at the proper word (E) or doubleword (D and L) boundary if a length is not specified. However, any length up to and including 8 bytes (E and D) or 16 bytes (L) can be specified by a length modifier. In this case, no boundary alignment occurs.

Any of the following statements could be used to specify 46.415 as a positive, fullword, floating-point constant; the last is a machine instruction statement with a literal operand. Note that each of the last two constants contains an exponent modifier.

Name	Operation	Operand
	DC	E'46.415'
	DC	E'46415E-3'
	DC	E'+464.15E-1'
	DC	E'+.46415E+2'
	DC	EE2'.46415'
	AE	6,=EE2'.46415'

The following would each be generated as doubleword floating-point constants.

Name	Operation	Operand
FLOAT	DC	DE+4'+46,-3.729,+473'

The DS instruction allows you to:

- Reserve areas of storage.
- Provide labels for these areas.
- Use these areas by referring to the symbols defined as labels.

The DS instruction causes no data to be assembled. Unlike the DC instruction, you do not have to specify the nominal value (fourth subfield) of a DS instruction operand. Therefore, the DS instruction is the best way of symbolically defining storage for work areas, input/output buffers, etc.

The format of the DS instruction is:

Name	Operation	Operand
Any symbol or blank	DS	One or more operands, separated by commas, written in the format described in the following text

The format of the DS operand is identical to that of the DC operand; exactly the same subfields are used and are written in exactly the same sequence as they are in the DC operand. Although the formats are identical, there are two differences in the specification of subfields. They are:

1. The nominal value subfield is optional in a DS operand, but it is mandatory in a DC operand. If a nominal value is specified in a DS operand, it must be valid.
2. The maximum length that can be specified for the character (C) and hexadecimal (X) type areas is 65,535 bytes rather than 256 bytes for the same DC operands.

The label used in the name entry of a DS instruction, as with the label for a DC instruction:

- Has an address value of the leftmost byte of the area reserved, after any boundary alignment is performed
- Has a length attribute value, depending on the implicit or explicit length of the type of area reserved

If the DS instruction is specified with more than one operand or more than one nominal value in the operand, the label addresses the area reserved for the field that corresponds to the first nominal value of the first operand. The length attribute value is equal to the length explicitly specified or implicit in the first operand.

Note: Unlike the DC instruction, bytes skipped for alignment are not set to zero. Also, nothing is assembled into the storage area reserved by a DS instruction. No assumption should be made as to the contents of the reserved area.

The size of a storage area that can be reserved by a DS instruction is limited only by the size of virtual storage or by the maximum value of the location counter, which is smaller.

TO RESERVE STORAGE: If you want to take advantage of automatic boundary alignment (if the ALIGN option is specified) and implicit length calculation, you should not supply a length modifier in your operand specifications. You should specify a type subfield that corresponds to the type of area you need for your instructions.

Note: Duplication has no effect on implicit length.

Using a length modifier can give you the advantage of explicitly specifying the length attribute value assigned to the label naming the area reserved. However, your areas will not be aligned automatically according to their type. If you omit the nominal value in the operand, you should use a length modifier for the binary (B), character (C), hexadecimal (X), and decimal (P and Z) type areas; otherwise, their labels will be given a length attribute value of 1.

When you need to reserve large areas, you can use a duplication factor. However, in this case, you can only refer to the first area by label. You can also use the character (C) and hexadecimal (X) field types to specify large areas using the length modifier.

Although the nominal value is optional for a DS instruction, you can put it to good use by letting the assembler compute the length for areas of the B, C, X, and decimal (P or Z) type areas. You achieve this by specifying the general format of the nominal value that will be placed in the area at execution time.

TO FORCE ALIGNMENT: You can use the DS instruction to force alignment to a boundary that otherwise would not be provided. You can force the location counter to a doubleword, fullword, or halfword boundary by using the appropriate field type (for example, D, F, or H) with a duplication factor of zero. No space is reserved for such an instruction, yet the data that follows is aligned on the desired boundary. For example, the following statements would set the location counter to the next doubleword boundary and reserve storage space for a 128-byte field (whose leftmost byte would be on a doubleword boundary).

Name	Operation	Operand
	DS	0D
AREA	DS	CL128

Note: Alignment is forced when either the ALIGN or the NOALIGN assembler option is set.

TO NAME FIELDS OF AN AREA: Using a duplication factor of zero in a DS instruction also allows you to provide a label for an area of storage without actually reserving the area. You can use DS or DC instructions to reserve storage for, and assign labels to, fields within the area. These fields can then be addressed symbolically. (Another way of accomplishing this is described in "DSECT—Identify Dummy Section" on page 58.) The whole area is addressable by its label. In addition, the symbolic label will have the length attribute value of the whole area. Within the area, each field is addressable by its label.

For example, assume that 80-character records are to be read into an area for processing and that each record has the following format:

Positions 5-10 Payroll Number

Positions 11-30 Employee Name

Positions 31-36 Date

Positions 47-54 Gross Wages

Positions 55-62 Withholding Tax

The following example illustrates how DS instructions might be used to assign a name to the record area, then define the fields of the area and allocate storage for them. Note that the first statement names the entire area by defining the symbol RDAREA; this statement gives RDAREA a length attribute of 80 bytes, but does not reserve any storage. Similarly, the fifth statement names a 6-byte area by defining the symbol DATE; the three subsequent statements actually define the fields of DATE and allocate storage for them. The second, ninth, and last statements are used for spacing purposes and, therefore, are not named.

Name	Operation	Operand
RDAREA	DS	0CL80
	DS	CL4
PAYNO	DS	CL6
NAME	DS	CL20
DATE	DS	0CL6
DAY	DS	CL2
MONTH	DS	CL2
YEAR	DS	CL2
	DS	CL10
GROSS	DS	CL8
FEDTAX	DS	CL8
	DS	CL18

Additional examples of DS statements are shown below:

Name	Operation	Operand
ONE	DS	CL80 (One 80-byte field, length attribute of 80)
TWO	DS	80C (80 1-byte fields, length attribute of 1)
THREE	DS	6F (6 fullwords, length attribute of 4)
FOUR	DS	D (1 doubleword, length attribute of 8)
FIVE	DS	4H (4 halfwords, length attribute of 2)

To define four 10-byte fields and one 100-byte field, the respective DS statements might be as follows:

Name	Operation	Operand
FIELD	DS	4CL10
AREA	DS	CL100

Although FIELD might have been specified as one 40-byte field, the preceding definition has the advantage of providing FIELD with a length attribute of 10. This would be pertinent when using FIELD as an SS machine instruction operand.

CCW OR CCW0—DEFINE CHANNEL COMMAND WORD (FORMAT 0)

You can use the CCW or CCW0 instruction to define and generate an 8-byte channel command word aligned at a doubleword boundary for input/output operations. The CCW and CCW0 instructions have identical functions; however, the CCW0 instruction is not included in the S/370 instruction set. A CCW or CCW0 will cause any bytes skipped to be zeroed. A CCW or CCW0 instruction will result in a Format 0 channel command word which allows 24-bit data addresses. The internal machine format of a channel command word is shown in Figure 33.

Byte	Bits	Usage
0	0-7	Command code
1-3	8-31	Address of data to operate upon
4	32-37	Flags
	38-39	Must be specified as zeros
5	40-47	Set to zeros by assembler
6-7	48-63	Byte count or length of data

Figure 33. Channel Command Word, Format 0

The format of the CCW or CCW0 instruction statement is:

Name	Operation	Operand
Any symbol or blank	CCW or CCW0	Command code, data address, flags, data count

All four operands must appear. They are written, from left to right, as follows:

1. An absolute expression that specifies the command code. This expression's value is right-justified in byte 0.

2. A relocatable or absolute expression specifying the address of the data to operate upon. This value is treated as a 3-byte, A-type address constant. The value of this expression is right-justified in bytes 1 through 3.

3. An absolute expression that specifies the flags for bits 32 through 37, and zeros for bits 38 and 39. The value of this expression is right-justified in byte 4. (Byte 5 is set to zero by the assembler.)

4. An absolute expression that specifies the byte count or length of data. The value of this expression is right-justified in bytes 6 and 7.

The generated channel command word is aligned on a doubleword boundary. Any bytes skipped are set to zero.

The symbol in the name field, if present, is assigned the value of the address of the leftmost byte of the channel command word generated. The length attribute value of the symbol is 8.

The following are examples of CCW and CCW0 statements:

Name	Operation	Operand
WRITE1	CCW	1,DATADR,X'48',X'50'
WRITE2	CCW0	1,DATADR,X'48',X'50'

The object code generated (in hexadecimal) for either of the above examples is:

```
01 xxxxxx 48 00 0050
```

where xxxxxx contains the address of DATADR, and DATADR must reside below 16 megabytes.

Notes:

1. If you use the EXCP access method, you must use CCW or CCW0, because EXCP does not support 31-bit data addresses in channel command words.

2. You should use RMODE 24 with CCW or CCW0 to ensure that valid data addresses are generated in the channel command words at execution time.

CCW1—DEFINE CHANNEL COMMAND WORD (FORMAT 1)

You can use the CCW1 instruction to specify the object code format to be used for an 8-byte channel command word aligned at a doubleword boundary for input/output operations. The object code for a Format 1 channel command word allows a 31-bit data address, whereas the object code generated by a CCW or CCW0 instruction allows only a 24-bit data address. A CCW1 will cause any bytes skipped to be zeroed. The internal machine format of a channel command word is shown in Figure 34 .

Byte	Bits	Usage
0	0-7	Command code
1	8-15	Flags
2-3	16-31	Count
4	32	Must be zero
4-7	33-63	Data address

Figure 34. Channel Command Word, Format 1

The format of the CCW1 instruction statement is:

Name	Operation	Operand
Any symbol or blank	CCW1	Command code, data address, flags, data count

All four operands must appear. They are written, from left to right, as follows:

1. An absolute expression that specifies the command code. This expression's value is right-justified in byte 0.

2. An expression specifying the data address. This value is treated as a 4-byte, A-type address constant. The value of this expression is in bytes 4 through 7, the first bit of which is set to 0.

3. An absolute expression that specifies the flags for bits 8 through 15. The value of this expression is right-justified in byte 1.

4. An absolute expression that specifies the count. The value of this expression is right-justified in bytes 2 and 3.

Note: The expression for the data address should be such that the address is within the range 0 to $2^{31}-1$, inclusive, after

possible relocation. This will be the case if the expression refers to a location within one of the control sections which will be link-edited together. An expression such as *-1000000000 will yield an acceptable value only when the command control word is placed in storage location 1000000000 or higher.

The generated channel command word is aligned on a doubleword boundary. Any bytes skipped are set to zero.

The symbol in the name field, if present, is assigned the value of the address of the leftmost byte of the channel command word generated. The length attribute value of the symbol is 8.

The following is an example of a CCW1 statement:

Name	Operation	Operand
A	CCW1	X'0C',BUF1,X'00',L'BUF1

The object code (in hexadecimal) generated in the above example is:

```
0C 00 yy xxxxxxxx
```

where yy is length of BUF1, and xxxxxxxx is BUF1 address.

Note: BUF1 can reside anywhere in virtual storage.

PROGRAM CONTROL INSTRUCTIONS

You use the program control instructions to:

- Specify the end of an assembly.
- Set the location counter to a value or word boundary.
- Insert previously written coding in the program.
- Specify the placement of literals in storage.
- Check the sequence of input cards.
- Indicate statement format.
- Punch a card.

Except for the CNOP and COPY instructions, none of these assembler instructions generate instructions or constants in the object program.

ICTL—INPUT FORMAT CONTROL

The ICTL instruction allows you to change the begin, end, and continue columns that establish the coding format of the assembler language source statements.

For example, with the ICTL instruction, you can increase the number of columns to be used for the identification or sequence checking of your source statements. By changing the begin column, you can even create a field before the begin column to contain identification or sequence numbers.

You can use the ICTL instruction only once, at the very beginning of a source program. If you do not use it, the assembler recognizes the standard values for the begin, end, and continue columns.

The format of the ICTL instruction statement is as follows:

Name	Operation	Operand
Blank	ICTL	1-3 decimal self-defining terms of the form b or b,e or b,e,c

The operand entry must be one to three decimal self-defining terms. There are only three possible ways of specifying the operand entry:

1. The operand b specifies the begin column of the source statement. It must always be specified, and must be within the range of 1 through 40, inclusive.

2. The operand e specifies the end column of the source statement. The end column, when specified, must be within the range of 41 through 80, inclusive; when not specified, it is assumed to be 71.

3. The operand c specifies the continue column of the source statement. The continue column, when specified, must be within the range of 2 through 40. If the continue column is not specified, or if column 80 is specified as the end column, the assembler assumes that continuation lines are not allowed.

If no ICTL statement is used in the source program, the assembler assumes that 1, 71, and 16 are the begin, end, and continue columns, respectively.

The values specified for the three operands depend on each other. Two rules governing the interaction of b, e, and c are:

1. The position of the end column must not be less than the position of the begin column +5, but must be greater than the position of the continue column.

2. The position of the continue column must be greater than that of the begin column.

The next example designates the begin column as 25. Since the end column is not specified, it is assumed to be column 71. No continuation cards are recognized because the continue column is not specified.

Name	Operation	Operand
	ICTL	25

Note: The ICTL instruction does not affect the format of statements brought in by a COPY instruction or generated from a library macro definition. The assembler processes these statements according to the standard begin, end, and continue columns described in "Field Boundaries" on page 9.

ISEQ—INPUT SEQUENCE CHECKING

You can use the ISEQ instruction to cause the assembler to check if the statements in a source module are in sequential order. In the ISEQ instruction, you specify the columns between which the assembler is to check for sequence numbers.

The assembler begins sequence checking with the first statement line following the ISEQ instruction. The assembler also checks continuation lines.

Sequence numbers on adjacent statements or lines are compared according to the 8-bit internal EBCDIC collating sequence. When the sequence number on one line is not greater than the sequence

number on the preceding line, a sequence error is flagged, and a warning message is issued, but the assembly is not terminated.

Note: If the sequence field in the preceding line is blank, the assembler uses the last preceding line with a nonblank sequence field to make its comparison.

The format of the ISEQ instruction statement is:

Name	Operation	Operand
Blank	ISEQ	Two decimal self-defining terms of the form l,r or blank

The first option in the operand entry must be two decimal self-defining terms. This format of the ISEQ instruction initiates sequence checking, beginning at the statement or line following the ISEQ instruction. Checking begins at the column represented by l and ends at the column represented by r. The second option of the ISEQ format terminates the sequence checking operation.

The rules for interaction are:

1. l specifies the leftmost column of the field to be checked, and r specifies the rightmost column of the field to be checked. r must be greater than or equal to l.

2. l and r can be anywhere on the cards in the input. Thus, they can also be between the begin and end columns.

Note: The assembler checks only those statements that are specified in the coding of a source module. This includes any COPY instruction statement or macro instruction.

However, the assembler does not check:

1. Statements inserted by a COPY instruction

2. Statements generated from model statements inside macro definitions or from model statements in open code (statement generation is discussed in detail in "Chapter 7. How to Prepare Macro Definitions" on page 151)

3. Statements in library macro definitions

PUNCH—PUNCH A CARD

The PUNCH instruction allows you to punch source or other statements into a single card. With this feature you can:

- Code PUNCH statements in a source module to produce control statements for the linkage editor. The linkage editor uses these control statements to process the object module.

- Code PUNCH statements in macro definitions to produce, for instance, source statements in other computer languages or for other processing phases.

The card that is punched has a physical position immediately after the PUNCH instruction and before any other TXT cards of the object decks that are to follow.

The PUNCH instruction causes the data in its operand to be punched into a card. One PUNCH instruction produces one punched card, but as many PUNCH instructions as necessary can be used.

The PUNCH instruction statement can appear anywhere in a source module except before and between source macro definitions. If a PUNCH instruction occurs before the first control section, the

resultant card punched will precede all other cards in the object deck.

The cards punched as a result of a PUNCH instruction are not a logical part of the object deck, even though they can be physically interspersed in the object deck.

The format of the PUNCH instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	PUNCH	A character string of up to 80 characters, enclosed in apostrophes

All 256 punch combinations of the IBM System/370 character set are allowed in the character string of the operand field. Variable symbols are also allowed.

The position of each character specified in the PUNCH statement corresponds to a column in the card to be punched. However, the following rules apply to ampersands and apostrophes:

1. A single ampersand initiates an attempt to identify a variable symbol and to substitute its current value.

2. Double ampersands or apostrophes are punched as single ampersands or apostrophes.

3. A single apostrophe followed by one or more blanks simply terminates the string of characters punched. If a nonblank character follows a single apostrophe, an error message is issued and nothing is punched.

Only the characters punched, including blanks, count toward the maximum of 80 allowed.

Notes:

1. No sequence number or identification is punched into the card produced.

2. If the NODECK option is specified when the assembler is invoked, no cards are punched, neither for the PUNCH or REPRO instructions, nor for the object deck of the assembly.

REPRO—REPRODUCE FOLLOWING CARD

The REPRO instruction causes the data specified in the statement that follows to be punched into a card. Unlike the PUNCH instruction, the REPRO instruction does not allow values to be substituted into variable symbols before the card is punched. One REPRO instruction produces one punched card.

The REPRO instruction can appear anywhere in a source module except before and between source macro definitions. The punched cards are not part of the object deck, even though they can be physically interspersed in the object deck.

The format of the REPRO instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	REPRO	Not required

The line to be reproduced can contain any of the 256 punch characters, including blanks, ampersands, and apostrophes. No substitution is performed for variable symbols.

Notes:

1. Sequence numbers and identification are not punched in the card.

2. If the NODECK option is specified in the job control language for the assembler program, no cards are punched: neither for the PUNCH or REPRO instructions, nor for the object deck of the assembly.

PUSH INSTRUCTION

The PUSH instruction allows you to save the current PRINT or USING status in "push-down" storage on a last-in, first-out basis. You can restore this PRINT and USING status later, also on a last-in, first-out basis, by using a corresponding POP instruction.

The format of the PUSH instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	PUSH	Option 1: PRINT Option 2: USING Option 3: PRINT,USING Option 4: USING,PRINT

One of the four options for the operand entry must be specified. The PUSH instruction does not change the status of the current PRINT or USING instructions; the status is only saved.

Note: When the PUSH instruction is used in combination with the POP instruction, a maximum of four nests of PUSH PRINT - POP PRINT or PUSH USING - POP USING are allowed.

POP INSTRUCTION

The POP instruction allows you to restore the PRINT or USING status saved by the most recent PUSH instruction.

The format of the POP instruction is:

Name	Operation	Operand
A sequence symbol or blank	POP	Option 1: PRINT Option 2: USING Option 3: PRINT,USING Option 4: USING,PRINT

One of the four options for the operand entry must be specified. The POP instruction causes the status of the current PRINT or USING instruction to be overridden by the PRINT or USING status saved by the last PUSH instruction.

Note: When the POP instruction is used in combination with the PUSH instruction, a maximum of four nests of PUSH PRINT - POP PRINT or PUSH USING - POP USING are allowed.

ORG—SET LOCATION COUNTER

You use the ORG instruction to alter the setting of the location counter and thus control the structure of the current control section. This allows you to redefine portions of a control section.

Using the Figure 35 on page 134 as an example, if you wish to build a translate table (for example, to convert EBCDIC character code into some other internal code):

- You define the table (see (1) in Figure 35) as being filled with zeros.
- You use the ORG instruction to alter the location counter so that its counter value indicates a desired location (see (2) in Figure 35) within the table.
- You redefine the data (see (3) in Figure 35) to be assembled into that location.
- After repeating the first three steps (see (4) in Figure 35) until your translate table is complete, you use an ORG instruction with a blank operand field to alter the location counter. The counter value then indicates the next available location (see (5) in Figure 35) in the current control section (after the end of the translate table).

Both the assembled object code for the whole table filled with zeros, and the object code for the portions of the table you redefined, are printed in the program listings. However, the data defined later is loaded over the previously defined zeros and becomes part of your object program, instead of the zeros.

In other words, the ORG instruction can cause the location to point to any part of a control section, even the middle of an instruction, into which you can assemble desired data. It can also cause the location counter to point to the next available location so that your program can continue to be assembled in a sequential fashion.

The format of the ORG instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	ORG	A relocatable expression or blank

In general, symbols used in the operand field need not have been previously defined. However, the relocatable component of the expression (that is, the unpaired relocatable term) must have been previously defined in the same control section in which the ORG statement appears, or be equated to a previously defined value.

The location counter is set to the value of the expression in the operand. If the operand is omitted, the location counter is set to the next available location for the current control section.

An ORG statement cannot be used to specify a location below the beginning of the control section in which it appears. For example, the following is invalid if it appears less than 500 bytes from the beginning of the current control section.

Name	Operation	Operand
	ORG	*-500

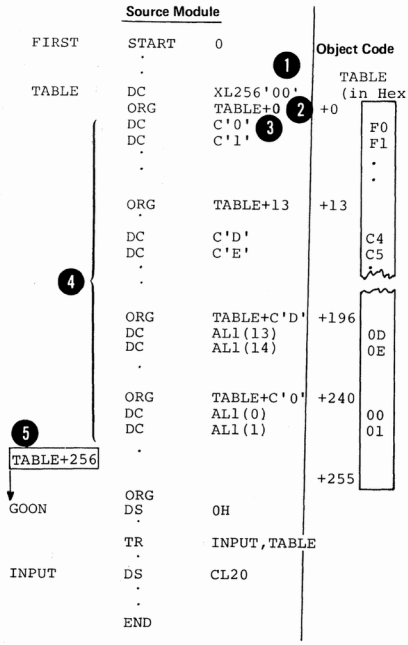


Figure 35. Building a Translate Table

This is because the expression specified is then negative, and will set the location counter to a value larger than the assembler can process. The location counter will "wrap around" (the location counter is discussed in detail in "Location Counter Reference" on page 27).

Note: With the ORG statement, you can give two instructions the same location counter values. In such a case, the second instruction will not always eliminate the effects of the first instruction. Consider the following example:

```
ADDR    DC  A(LOC)
        ORG *-4
B       DC  C'BETA'
```

In this example, the value of B (BETA) will be destroyed by the relocation of ADDR during linkage editing.

RESTRICTION ON ORG WHEN THE LOCTR INSTRUCTION IS USED: If you specify multiple location counters with the LOCTR instruction, the ORG instruction can alter only the location counter in use when the instruction appears. Thus, you cannot control the structure of the whole control section using ORG, but only the part that is controlled by the current location counter.

LTORG—BEGIN LITERAL POOL

You use the LTORG instruction so that the assembler can collect and assemble literals into a literal pool. A literal pool contains the literals you specify in a source module either:

- After the preceding LTORG instruction, or
- After the beginning of the source module.

The assembler ignores the borders between control sections when it collects literals into pools. Therefore, you must be careful to include the literal pools in the control sections to which they belong (for details, see "Addressing Considerations" on page 136).

The creation of a literal pool gives the following advantages:

- Automatic organization of the literal data into sections that are properly aligned and arranged so that no space is wasted.
- Assembling of duplicate data into the same area.
- Because all literals are cross-referenced, you can find the literal constant in the pool into which it has been assembled.

The format of the LTORG instruction statement is:

Name	Operation	Operand
Any symbol or blank	LTORG	Not used

If an ordinary symbol is specified in the name field, it represents the first byte of the literal pool; this symbol is aligned on a doubleword boundary and has a length attribute value of 1. If bytes are skipped after the end of a literal pool to achieve alignment for the next instruction, constant, or area, the bytes are not filled with zeros.

Literal Pool

A literal pool is created immediately after a LTORG instruction or, if no LTORG instruction is specified, at the end of the first control section.

Each literal pool has four segments into which the literals are stored (a) in the order that the literals are specified, and (b) according to their assembled lengths, which, for each literal, is the total explicit or implied length), as described below.

- The first segment contains all literal constants whose assembled lengths are a multiple of 8.

- The second segment contains those whose assembled lengths are a multiple of 4, but not of 8.
- The third segment contains those whose assembled lengths are even, but not a multiple of 4.
- The fourth segment contains all the remaining literal constants whose assembled lengths are odd.

Since each literal pool is aligned on a doubleword boundary, this guarantees that all literals in the first segment are doubleword aligned; in the second segment, fullword aligned; and, in the third, halfword aligned. No space is wasted except, possibly, at the origin of the pool.

Literals from the following statement are in the pool, in the segments indicated by the parenthesized numbers:

```
FIRST  START   0
         .
       MVC     TO,=3F'9'     (2)
       AD      2,=D'7'       (1)
       IC      2,=XL1'8'     (4)
               ,=CL3'JAN'    (4)
               ,=2F'1,2'     (1)
               ,=H'33'       (3)
               ,=A(ADDR)     (2)
               ,=XL8'05'     (1)
```

Addressing Considerations

If you specify literals in source modules with multiple control sections, you should:

- Write a LTORG instruction at the end of each control section, so that all the literals specified in the section are assembled into the one literal pool for that section. If a control section is divided and interspersed among other control sections, you should write a LTORG instruction at the end of each segment of the interspersed control section.
- When establishing the addressability of each control section, make sure (a) that the entire literal pool for that section is also addressable, by including it within a USING range, and (b) that the literal specifications are within the corresponding USING domain. The USING range and domain are described in "USING—Use Base Address Register" on page 41.

Note: All the literals specified after the last LTORG instruction, or, if no LTORG instruction is specified, all the literals in a source module are assembled into a literal pool at the end of the first control section. You must then make this literal pool addressable, along with the addresses in the first control section. This literal pool is printed in the program listing after the END instruction.

Duplicate Literals

If you specify duplicate literals within the part of the source module that is controlled by a LTORG instruction, only one literal constant is assembled into the pertinent literal pool. This also applies to literals assembled into the literal pool at the end of the first or only control section of a source module that contains no LTORG instructions.

Literals are duplicates only if their specifications are identical, not if the object code assembled happens to be identical.

When two literals specifying identical A-type (or Y-type) address constants contain a reference to the value of the

location counter (*), both literals are assembled into the literal pool. This is because the value of the location counter is different in the two literals.

The following examples illustrate how the assembler stores pairs of literals, if the placement of each pair is controlled by the same LTORG statement.

X'F0' C'0'	Both are stored
XL3'0' HL3'0'	Both are stored
A(*+4) A(*+4)	Both are stored
X'FFFF' X'FFFF'	Identical; the first is stored

CNOP—CONDITIONAL NO OPERATION

You can use the CNOP instruction to align any instruction or other data on a specific halfword boundary. The CNOP instruction ensures an unbroken flow of executable instructions by generating no-operation instructions to fill the bytes skipped to perform the alignment that you specified.

For example, when you code the linkage to a subroutine, you may wish to pass parameters to the subroutine in fields immediately following the branch and link instructions. These parameters—for example, channel command words—can require alignment on a specific boundary.

The subroutine can then address the parameters you pass through the register with the return address. This is illustrated below:

Name	Operation	Operand
LINK	CNOP BALR CCW	6,8 2,10 1,DATADR,X'48',X'50'

Assume that the location counter is currently aligned at a doubleword boundary. Then the CNOP instruction in the following sequence causes three branch-on-conditions (no-operations) to be generated, thus aligning the BALR instruction at the last halfword in a doubleword as follows:

Name	Operation	Operand
	BCR BCR BCR	0,0 0,0 0,0
LINK	BALR CCW	2,10 1,DATADR,X'48',X'50'

After the BALR instruction is generated, the location counter is at a doubleword boundary, thereby ensuring that the CCW instruction immediately follows the branch and link instruction.

The CNOP instruction forces the alignment of the location counter to a halfword, fullword, or doubleword boundary. It does not affect the location counter if the counter is already properly aligned. If the specified alignment requires the location counter to be incremented, one to three no-operation instructions (BCR 0,0 occupying two bytes each) are generated to fill the skipped bytes. Any single byte skipped to achieve alignment to the first no-operation instruction is filled with zeros.

The format of the CNOP instruction statement is:

Name	Operation	Operand
Any symbol or blank	CNOP	Two absolute expressions of the form b,w

The operands must be absolute expressions, and the symbols in them need not be previously defined. The first operand, b, specifies at which even-numbered byte in a fullword or doubleword the location counter is set. The second operand, w, specifies whether the byte is in a fullword (w=4) or a doubleword (w=8).

Valid pairs of b and w are indicated below:

b,w	Specifies
0,4	Beginning of a word
2,4	Middle of a word
0,8	Beginning of a doubleword
2,8	Second halfword of a doubleword
4,8	Middle (third halfword) of a doubleword
6,8	Fourth halfword of a doubleword

Figure 36 shows the position in a doubleword that each of these pairs specifies. Note that both 0,4 and 2,4 specify two locations in a doubleword.

Doubleword							
Fullword				Fullword			
Halfword		Halfword		Halfword		Halfword	
Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
0,4 0,8		2,4 2,8		0,4 4,8		2,4 6,8	

Figure 36. CNOP Alignment

COPY—COPY PREDEFINED SOURCE CODING

You use the COPY instruction to obtain source language coding from a library and include it in the programs currently being assembled. You thereby avoid writing the same, often-used sequence of code over and over. The format of the COPY instruction statement is as follows:

Name	Operation	Operand
Blank	COPY	One ordinary symbol

The operand is a symbol that identifies a partitioned data set member to be copied from either the system macro library or a user library concatenated to it.

The source coding that is copied into a source module:

- Is inserted immediately after the COPY instruction
- Is inserted and processed according to the standard instruction statement coding format, even if an ICTL instruction has been specified
- Must not contain either an ICTL or ISEQ instruction
- Can contain other COPY statements[1]
- Can contain macro definitions

If a source macro definition is copied into the beginning of a source module, both the MACRO and MEND statements that delimit the definition must be contained in the same level of copied code.

Notes:

1. The COPY instruction can also be used to copy statements into source macro definitions.
2. The rules that govern the occurrence of assembler language statements in a source module also govern the statements copied into the source module.

END—END ASSEMBLY

You use the END instruction to terminate the assembly of a program. You can also supply an address in the operand field to which control may be transferred after the program is loaded. The END instruction must always be the last statement in the source program.

The format of the END instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	END	A relocatable expression or blank

The operand specifies the point to which control may be transferred when loading is complete. This point is usually the address of the first executable instruction in the program, as shown in the following sequence.

---

[1] There are no restrictions on the number of levels of nested copy instructions. However, the COPY nesting must not be recursive. Thus, if the statement 'COPY A' is coded, and A contains a statement 'COPY B', B must not contain a statement 'COPY A'.

Name	Operation	Operand
NAME	CSECT	
AREA	DS	50F
BEGIN	BALR	2,0
	USING	*,2
	.	
	.	
	.	
	END	BEGIN

If specified, the operand entry can be generated by substitution into variable symbols. However, after substitution, that is, at assembly time:

- It must be a relocatable expression representing an address in the source module delimited by the END instruction, or
- If it contains an external symbol, the external symbol must be the only term in the expression, or the remaining terms in the expression must reduce to zero.
- It must not be a literal.

LISTING CONTROL INSTRUCTIONS

The instructions described in this section request the assembler to produce listings and identify output cards in the object deck according to your special needs. They allow you to determine printing and page formatting options other than the ones the assembler program assumes by default. Among other things, you can introduce your own page headings, control line spacing, and suppress unwanted detail.

TITLE—IDENTIFY ASSEMBLY OUTPUT

The TITLE instruction allows you to:

- Provide headings for each page of the assembly listing of your source modules.
- Identify the assembly output cards of your object modules. You can specify up to 8 identification characters that the assembler will punch into all the output cards, beginning at column 73. The assembler punches sequence numbers into the columns that are left, up to column 80.

The format of the TITLE instruction statement is:

Name	Operation	Operand
A string of alphameric characters, a variable symbol, a combination of above, a sequence symbol, or a blank	TITLE	A character string up to 100 characters, enclosed in apostrophes

The first three options for the name field have a special significance only for the first TITLE instruction in which they are specified. For subsequent TITLE instructions, the first three options do not apply.

For the first TITLE instruction of a source module that has a nonblank name entry that is not a sequence symbol, up to 8

alphameric characters can be specified in any combination in the name field.

These characters are punched as identification, beginning at column 73, into all the output cards from the assembly, except those produced by the PUNCH and REPRO instructions. The assembler substitutes the current value into a variable symbol and uses the generated result as identification characters.

If a valid ordinary symbol is specified, its appearance in the name field does not constitute a definition of that symbol for the source module. It can, therefore, be used in the name field of any other statement in the same source module.

The character string in the operand field is printed as a heading at the top of each page of the assembly listing. The heading is printed beginning on the page in the listing following the page on which the TITLE instruction is specified. A new heading is printed when a subsequent TITLE instruction appears in the source module.

For example, if the following statement is the first TITLE statement to appear in a program:

Name	Operation	Operand
PGM1	TITLE	'FIRST HEADING'

then PGM1 is punched into all of the output cards (columns 73 through 76) and this heading appears at the top of each subsequent page: PGM1 FIRST HEADING.

If the following statement occurs later in the program:

Name	Operation	Operand
	TITLE	'A NEW HEADING'

then PGM1is still punched into the output cards, but each following page begins with the heading: PGM1 A NEW HEADING.

Each TITLE statement causes the listing to be advanced to a new page (before the heading is printed), except when PRINT NOGEN is in use.

Any printable character specified will appear in the heading, including blanks. Variable symbols are allowed. However, the following rules apply to ampersands and apostrophes:

- A single ampersand initiates an attempt to identify a variable symbol and to substitute its current value.
- Double ampersands or apostrophes specified, print as single ampersands or apostrophes in the heading.
- A single apostrophe followed by one or more blanks simply terminates the heading prematurely. If a nonblank character follows a single apostrophe, the assembler issues an error message and prints no heading.

Only the characters printed in the heading count toward the maximum of 100 characters allowed.

Note: The TITLE statement itself is not printed in an assembly listing.

EJECT—START NEW PAGE

The EJECT instruction allows you to stop the printing of the assembler listing on the current page, and continue the printing on the next page.

The format of the EJECT instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	EJECT	Not required

The EJECT instruction causes the next line of the assembly listing to be printed at the top of a new page. If the line before the EJECT statement appears at the bottom of a page, the EJECT statement has no effect. An EJECT instruction immediately following another EJECT instruction causes a blank page in the listing.

Note: The EJECT instruction statement itself is not printed in the listing.

SPACE—SPACE LISTING

You can use the SPACE instruction to insert one or more blank lines in the listing of a source module. This allows you to separate sections of code on the listing page.

The format of the SPACE instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	SPACE	A decimal self-defining term or blank

The operand entry specifies the number of lines to be left blank. A blank operand entry causes one blank line to be inserted. A blank operand causes one blank line to be inserted. If the operand specified has a value greater than the number of lines remaining on the listing page, the instruction will have the same effect as an EJECT statement.

Note: The SPACE instruction itself is not printed in the listing.

The PRINT instruction allows you to control the amount of detail you wish printed in the listing of your programs. The three options that you can set are given in the table below:

Hierarchy	Description	Options
1	A listing is printed. No listing is printed.	ON OFF
2	All statements generated by the processing of a macro instruction are printed. Statements generated by the processing of a macro instruction are not printed.[1]	GEN NOGEN
3	Constants are printed in full in the listing. Only the leftmost 8 bytes of constants are printed in the listing	DATA NODATA

Note:

[1] The MNOTE instruction always causes a message to be printed.

The options are listed in hierarchic order; if OFF is specified, GEN and DATA will not apply. If NOGEN is specified, DATA will not apply to constants that are generated. The standard options inherent in the assembler program are ON, GEN, and NODATA.

The format of the PRINT instruction statement is:

Name	Operation	Operand
A sequence symbol or blank	PRINT	[ON|OFF] [,GEN|NOGEN] [,NODATA|DATA]

Note: Any sequence of specification is allowed.

At least one of the operands must be specified, and at most one of the options from each group. The PRINT instruction can be specified any number of times in a source module, but only those print options actually specified in the instruction change the current print status.

PRINT options can be generated by macro processing, at preassembly time. However, at assembly time, all options are in force until the assembler encounters a new and opposite option in a PRINT instruction.

The PUSH and POP instructions, described in "PUSH Instruction" on page 132 and "POP Instruction" on page 132, also influence the PRINT options by saving and restoring the PRINT status.

Note: The option specified in a PRINT instruction takes effect after the PRINT instruction. If PRINT OFF is specified, the PRINT instruction itself is printed, but not the statements that follow it. If the NOLIST assembler option is specified when the assembler is invoked, the entire listing for the assembly is suppressed.

Chapter 6 describes the macro instruction statement, definition, library, and so on.

Chapters 7 and 8 describe the basic rules for preparing macro definitions and for writing macro instructions.

Chapter 9 describes the rules for writing conditional assembly instructions.

In addition, Appendix D contains a reference summary of the entire macro language.

Examples of the features of the language appear throughout this part of the manual. These examples illustrate the use of particular features. However, they are not intended to show the full versatility of these features.

CHAPTER 6. INTRODUCTION TO MACRO LANGUAGE

This chapter introduces the basic macro concept: what you can use the macro facility for, how you can prepare your own macro definitions, and how you call these macro definitions for processing by the assembler.

Macro language is an extension of assembler language. It provides a convenient way to generate a desired sequence of assembler language statements many times in one or more programs. A macro definition is written only once; thereafter, a single statement, a macro instruction statement, is written each time you want to generate the desired sequence of statements. This simplifies the coding of programs, reduces the chance of programming errors, and ensures that standard sequences of statements are used to accomplish desired functions.

In addition, conditional assembly allows you to code statements that may or may not be assembled, depending upon conditions evaluated at assembly time. These conditions are usually tests of values which may be defined, set, changed, and tested during assembly. Conditional assembly can be used without using macro instruction statements.

USING MACROS

The main use of macros is to insert assembler language statements into a source program.

You call a named sequence of statements (the macro definition) by using a macro instruction, or macro call. The assembler replaces the macro call by the statements from the macro definition and inserts them into the source module at the point of call. The process of inserting the text of the macro definition is called macro generation or macro expansion. The assembler expands a macro at preassembly time.

The expanded stream of code then becomes the input for processing at assembly time; that is, the time at which the assembler translates the machine instructions into object code.

MACRO DEFINITION

A macro definition is a named sequence of statements you can call with a macro instruction. When it is called, the assembler processes and usually generates assembler language statements from the definition into the source module. The statements generated can be:

- Copied directly from the definition
- Modified by parameter values before generation
- Manipulated by internal macro processing to change the sequence in which they are generated

You can define your own macro definitions in which any combination of these three processes can occur. Some macro definitions, like some of those used for system generation, do not generate assembler language statements, but perform only internal processing.

A macro definition provides the assembler with (1) the name of the macro, (2) the parameters used in the macro, and (3) the sequence of statements the assembler generates when the macro instruction appears in the source program.

Every macro definition consists of a macro definition header statement (MACRO); a macro instruction prototype statement; one or more assembler language statements; and a macro definition trailer statement (MEND), as shown in Figure 37.

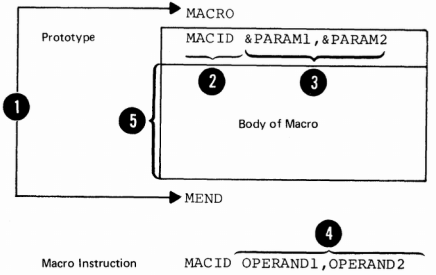


Figure 37. Parts of a Macro Definition

- The macro definition header and trailer statements (MACRO and MEND) indicate to the assembler the beginning and end of a macro definition (see (1) in Figure 37).
- The macro instruction prototype statement is used to name the macro (see (2) in Figure 37), and to declare its parameters (see (3) in Figure 37). In the operand field of the macro instruction, you can assign values (see (4) in Figure 37) to the parameters declared for the called macro definition.
- The body of a macro definition (see (5) in Figure 37) contains the statements that will be generated when you call the macro. These statements are called model statements; they are usually interspersed with conditional assembly statements or other processing statements.

Model Statements

You can also write assembler language statements as model statements. When it expands the macro, the assembler copies them exactly as they are written. You can also use variable symbols as points of substitution in a model statement. The assembler will enter values in place of these points of substitution each time the macro is called.

The three types of variable symbols in the assembler language are:

- Symbolic parameters, declared in the prototype statement
- System variable symbols
- SET symbols, which are part of the conditional assembly language

The assembler processes the generated statements, with or without value substitution, at assembly time.

Processing Statements

Processing statements perform functions at preassembly time when macros are expanded, but they are not themselves generated for further processing at assembly time. The processing statements are:

- Conditional assembly instructions
- Inner macro calls
- MNOTE instructions
- MEXIT instructions
- AREAD instructions

The MNOTE instruction allows you to generate an error message with an error condition code attached, or to generate comments in which you can display the results of preassembly computation.

The MEXIT instruction tells the assembler to stop processing a macro definition. The MEXIT instruction, therefore, provides an exit from the middle of a macro definition.

The MEND instruction not only delimits the contents of a macro definition, but also provides an exit from the definition.

The AREAD instruction allows you to assign to a SETC symbol the character string value of a statement that is placed immediately after a macro instruction.

Comments Statements

One type of comments statement describes preassembly operations and is not generated. The other type describes assembly-time operations and is, therefore, generated.

MACRO INSTRUCTION STATEMENT

A macro instruction statement (hereafter called a macro instruction) is a source program statement that you code to tell the assembler to process a particular macro definition. The assembler generates a sequence of assembler language statements for each occurrence of the same macro instruction. The generated statements are then processed as any other assembler language statement.

The macro instruction provides the assembler with:

- The name of the macro definition to be processed.
- The information or values to be passed to the macro definition. The assembler uses the information either in processing the macro definition or for substituting values into a model statement in the definition.

The output from a macro definition, called by a macro instruction, can be:

- A sequence of statements generated from the model statements of the macro for further processing at assembly time.
- Values assigned to global SET symbols. These values can be used in other macro definitions and in open code.

You can call a macro definition by specifying a macro instruction anywhere in a source module. You can also call a

macro definition from within another macro definition. This type of call is an inner macro call; it is said to be nested in the macro definition.

SOURCE AND LIBRARY MACRO DEFINITIONS

You can include a macro definition in a source module. This type of definition is called a source macro definition.

You can also insert a macro definition into a system or user library (located, for example, on disk) by using the appropriate utility program. This type of definition is called a library macro definition. The IBM-supplied macro definitions are examples of library macro definitions.

You can call a source macro definition only from the source module in which it is included. You can call a library macro definition from any source module.

Source and library macros are expanded in the same way, but syntax errors are handled differently. In source macros, error messages are attached to the statements in error. In library macros, however, error messages cannot be associated with the statement in error, because these macros are located and edited after the entire source module has been read. Therefore, the error messages are associated with the END statement.

Because of the difficulty of finding syntax errors in library macros, a macro definition should be run and "debugged" as a source macro before it is placed in a macro library.

MACRO LIBRARY

The same macro definition may be made available to more than one source program by placing the macro definition in the macro library. The macro library is a collection of macro definitions that can be used by all the assembler language programs in an installation. Once a macro definition has been placed in the macro library, it may be used by writing its corresponding macro instruction in a source program. Macro definitions must be in the system macro library under the same name as the prototype. The procedure for placing macro definitions in the macro library is described in the appropriate utilities manual.

SYSTEM MACRO INSTRUCTIONS

The macro instructions that correspond to macro definitions prepared by IBM are called system macro instructions. System macro instructions are described in the appropriate supervisor services and macro instructions and data management macro instructions manuals.

CONDITIONAL ASSEMBLY LANGUAGE

The conditional assembly language is a programming language with most of the features that characterize a programming language. For example, it provides:

- Variables
- Data attributes
- Expression computation
- Assignment instructions
- Labels for branching

- Branching instructions
- Substring operators that select characters from a string

You can use the conditional assembly language in a macro definition to receive input from a calling macro instruction. You can produce output from the conditional assembly language by using the MNOTE instruction.

You can use the functions of the conditional assembly language to select statements for generation, to determine their order of generation, and to perform computations that affect the content of the generated statements.

The conditional assembly language is described in "Chapter 9. How to Write Conditional Assembly Instructions."

CHAPTER 7. HOW TO PREPARE MACRO DEFINITIONS

Defining a macro means preparing the statements that constitute a macro definition. To define a macro you must:

- Give it a name.
- Declare any parameters to be used.
- Write the statements it contains.
- Establish its boundaries with a MACRO and a MEND instruction.

Except for conditional assembly instructions, this chapter describes all the statements that can be used to prepare macro definitions. Conditional assembly instructions are described in "Chapter 9. How to Write Conditional Assembly Instructions" on page 195.

WHERE TO DEFINE A MACRO IN A SOURCE MODULE

Macro definitions can appear anywhere in a source module. They remain in effect for the rest of your source module, or until another macro definition defining a macro with the same operation code is encountered. Thus, you can redefine a macro at any point in your program. The new definition will be used for all subsequent calls to the macro in the program.

This type of macro definition is called a source macro definition. A macro definition can also reside in a system library; this type of macro is called a library macro definition. Either type can be called from the source module by the appropriate macro instruction.

Macro definitions can also appear inside other macro definitions. There is no limit to the levels of macro definitions permitted.

The assembler does not process inner macro definitions until it finds the definition during the processing of a macro instruction calling the outer macro.

Consider the following example:

```
Name  Operation  Operand          Remarks

      MACRO                       macro header for outer macro
      OUTER      &A,&C=           macro prototype
      AIF        ('&C' EQ '').A
      MACRO                       macro header for inner macro
      INNER                       macro prototype
      .
      .
      MEND                        macro trailer for inner macro
.A    ANOP
      .
      MEND                        macro trailer for outer macro
```

The assembler does not process the macro definition for INNER until OUTER is called with a value for &C other than a null string.

OPEN CODE

Open code is that part of a source module that lies outside of any source macro definition. At coding time, it is important to

distinguish between source statements that lie in open code, and those that lie inside macro definitions.

FORMAT OF A MACRO DEFINITION

The general format of a macro definition is shown in Figure 38. The four parts are described in detail below:

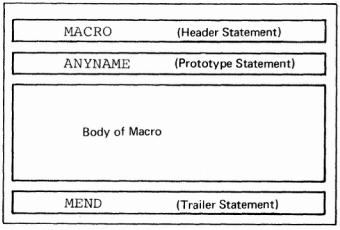


Figure 38. Format of a Macro Definition

MACRO—MACRO DEFINITION HEADER

You use the macro definition header statement to indicate the beginning of a macro definition. It must be the first statement in every macro definition. The format of this statement is:

Name	Operation	Operand
Blank	MACRO	Blank

MEND—MACRO DEFINITION TRAILER

You use the macro definition trailer statement to indicate the end of a macro definition. It also provides an exit when it is processed during macro expansion. It can appear only once within a macro definition and must be the last statement in every macro definition. The format of this statement is:

Name	Operation	Operand
A sequence symbol or blank	MEND	Blank

MACRO INSTRUCTION PROTOTYPE

You use the macro instruction prototype statement (hereafter called the prototype statement) to specify the mnemonic operation code and the format of all macro instructions that you use to call the macro definition.

The prototype statement must be the second noncomment statement in every macro definition. Only internal comments statements are allowed between the macro header and the macro prototype. Internal comments statements are listed only with the macro definition.

The format of this statement is:

Name	Operation	Operand
A name field parameter or blank	A symbol (mandatory)	Zero or more symbolic parameters separated by commas

The symbolic parameters are used in the macro definition to represent the operands of the corresponding macro instruction. A description of symbolic parameters appears under "Symbolic Parameters" on page 160.

NAME FIELD

You can write a name field parameter, similar to the symbolic parameter, as the name entry of a macro prototype statement. You can then assign a value to this parameter from the name entry in the calling macro instruction.

If used, the name entry must be a variable symbol. If this parameter also appears in the body of a macro, it will be given the value assigned to the parameter in the name field of the corresponding macro instruction. Note that the value assigned to the name field parameter has special restrictions that are listed in "Formatting Specifications" on page 11.

OPERATION FIELD

The symbol in the operation field of the prototype statement establishes the name by which a macro definition must be called. This name becomes the operation code required in any macro instruction that calls the macro.

Any operation code can be specified in the prototype operation field. If the entry is the same as an assembler or a machine operation code, the new definition overrides the previous use of the symbol. The same is true if the specified operation code has been defined earlier in the program as a macro, or is the operation code of a library macro.

OPERAND FIELD

The operand field in a prototype statement allows you to specify positional or keyword parameters. These parameters represent the values you can pass from the calling macro instruction to the statements within the body of a macro definition.

The operand field of the macro prototype statement must contain 0 to 240 symbolic parameters separated by commas. They can be positional parameters or keyword parameters, or both.

If no parameters are specified in the operand field and if the absence of the operand entry is indicated by a comma preceded and followed by one or more blanks, remarks are allowed.

The following is an example of a prototype statement:

Name	Operation	Operand
&NAME	MOVE	&TO,&FROM

Alternative Ways of Coding the Prototype Statement

The prototype statement can be specified in one of the following three ways:

- The normal way, with all the symbolic parameters preceding any remarks
- An alternative way, allowing remarks for each parameter
- A combination of the first two ways

The following examples illustrate (1) the normal statement format, (2) the alternative statement format, and (3) a combination of both statement formats.

Name	Operation	Operand Remarks
NAME1	OP1	&OPERAND1,&OPERAND2,&OPERAN X D3 THIS IS THE NORMAL X STATEMENT FORMAT
NAME2	OP2	&OPERAND1, THIS IS THE AL X &OPERAND2 TERNA X TE STATEMENT FORMAT
NAME3	OP3	&OPERAND1, THIS IS A COMB X &OPERAND2,&OPERAND3,&OPERAN X D4,&OPERAND5 INATION OF X BOTH STATEMENT FORMATS

Notes:

1. Any number of continuation lines are allowed. However, each continuation line must be indicated by a nonblank character in the column after the end column on the preceding card.
2. For each continuation line, the operand field entries (symbolic parameters) must begin in the continue column; otherwise, the whole line and any lines that follow will be considered to contain remarks.
3. The standard value for the continue column is 16, and, for the column after the end column, is 72.
4. A comma is required after each parameter except the last.
5. One or more blanks is required between the operand and the remarks.

BODY OF A MACRO DEFINITION

The body of a macro definition contains the sequence of statements that constitutes the working part of a macro. You can specify:

1. Model statements to be generated
2. Processing statements that, for example, can alter the content and sequence of the statements generated or issue error messages

3. Comments statements, some of which are generated and others which are not
4. Conditional assembly instructions to compute results to be generated

The statements in the body of a macro definition must appear between the macro prototype statement and the MEND statement of the definition. Numbers 1 through 3 in the list above are the three main types of statements allowed in the body of a macro. The body of a macro definition can be empty, that is, contain no statements.

Note: You can include macro definitions in the body of a macro definition. This is explained under "Using a Macro Definition" in this chapter.

MODEL STATEMENTS

Model statements are statements from which assembler language statements are generated at preassembly time. They allow you to determine the form of the statements to be generated. By specifying variable symbols as points of substitution in a model statement, you can vary the contents of the statements generated from that model statement. You can also use model statements into which you substitute values in open code.

A model statement consists of one or more fields, separated by one or more blanks, in columns 1 to 71. The fields are called the name, operation, operand, and remarks fields.

Each field or subfield can consist of:

- An ordinary character string composed of alphameric and special characters
- A variable symbol as a point of substitution
- Any combination of ordinary character strings and variable symbols to form a concatenated string.

The statements generated at preassembly time from model statements must be valid machine or assembler instructions, but must not be conditional assembly instructions. They must obey the coding rules described in "Rules for Model Statement Fields" on page 157or they will be flagged as errors at assembly time.

Examples:

```
LABEL    L 3,AREA
LABEL    L 3,20(4,5)
&LABEL   L 3,&AREA
FIELD&A  L 3,AREA&C
```

VARIABLE SYMBOLS AS POINTS OF SUBSTITUTION

Values can be substituted for variable symbols that appear in the name, operation, and operand fields of model statements; thus, variable symbols represent points of substitution. The three main types of variable symbol are:

- Symbolic parameters (positional or keyword)
- System variable symbols (&SYSLIST, &SYSNDX, &SYSECT, &SYSPARM, &SYSDATE, &SYSLOC, and &SYSTIME)
- SET symbols (global or local SETA, SETB, or SETC symbols)

Examples of subscripted variable symbols:

```
&PARAM(3)
&SYSLIST(1,3)
&SYSLIST(2)
&SETA(10)
&SETC(15)
```

Note: Symbolic parameters, SET symbols, and the system variable symbol, &SYSLIST, can all be subscripted. The remaining system variable symbols (&SYSNDX, &SYSECT, &SYSPARM, &SYSDATE, &SYSLOC, and &SYSTIME) cannot be subscripted.

LISTING OF GENERATED FIELDS

The different fields in a macro-generated statement or a statement generated in open code appear in the listing in the same column as they are coded in the model statement, with the following exceptions:

- If the substituted value in the name or operation field is too large for the space available, the next field will be moved to the right with one blank separating the fields.
- If the substituted value in the operand field causes the remarks field to be displaced, the remarks field is written on the next line, starting in the column where it is coded in the model statement.
- If the value substituted in the operation field of a macro-generated statement contains leading blanks, the blanks are ignored.
- If the value substituted in the operation field of a model statement in open code contains leading blanks, the blanks will be used to move the field to the right.
- If the value substituted in the operand field contains leading blanks, the blanks will be used to move the field to the right.
- If the value substituted contains trailing blanks, the blanks are ignored.

RULES FOR CONCATENATION

If a symbolic parameter in a model statement is immediately preceded or followed by other characters or another symbolic parameter, the characters that correspond to the symbolic parameter are combined in the generated statement with the other characters or the characters that correspond to the other symbolic parameter. This process is called concatenation.

When variable symbols are concatenated to ordinary character strings, the following rules apply to the use of the concatenation character (a period). The concatenation character is mandatory when:

(1) An alphameric character is to follow a variable symbol.

(2) A left parenthesis that does not enclose a subscript is to follow a variable symbol.

(3-4) A period (.) is to be generated. Two periods must be specified in the concatenated string following a variable symbol.

The concatenation character is not required when:

(5) An ordinary character string precedes a variable symbol.

(6) A special character, except a left parenthesis or a period, is to follow a variable symbol.

(7) A variable symbol follows another variable symbol.

(8) The concatenation character must not be used between a variable symbol and its subscript; otherwise, the characters will be considered a concatenated string and not a subscripted variable symbol.

Figure 39 on page 158, in which the circled numbers correspond to the numbers in the above list, gives the rules for concatenating variable symbols to ordinary character strings.

RULES FOR MODEL STATEMENT FIELDS

The fields that can be specified in model statements are the same fields that can be specified in an ordinary assembler language statement. They are the name, operation, operand, and remarks fields. It is also possible to specify a continuation-indicator field, an identification-sequence field, and a field before the begin column, if the appropriate ICTL instruction has been specified. Character strings in the last three fields (in the standard format only, columns 72 through 80) are generated exactly as they appear in the model statement, and no values are substituted for variable symbols.

Model statements must have an entry in the operation field, and, in most cases, an entry in the operand field in order to generate valid assembler language instructions.

NAME FIELD: The entries allowed in the name field of a model statement, before generation, are given below.

Blank
Ordinary symbol
Sequence symbol
Variable symbol
Any combination of variable symbols and other character strings concatenated together

The generated result must either be a blank or a valid ordinary symbol.

Variable symbols must not be used to generate comments statement indicators (* or .*).

Note: Restrictions on the name entry are further specified where each individual assembler language instruction is described in this manual.

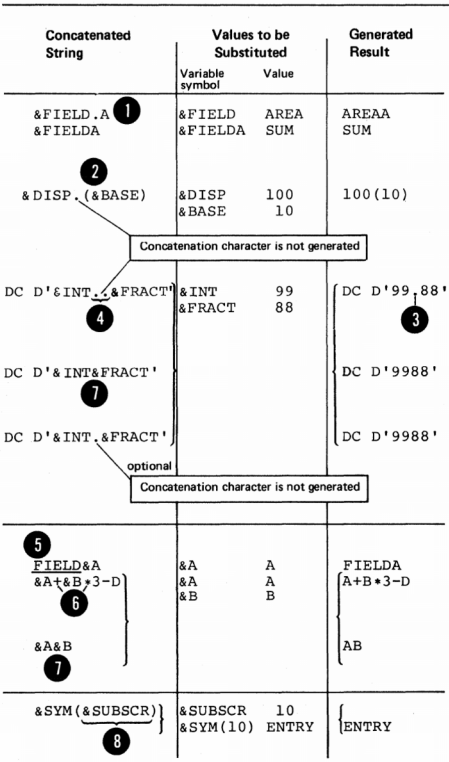


Figure 39. Rules for Concatenation

OPERATION FIELD: The entries allowed in the operation field of a

- Any machine instruction
- A macro instruction
- The following assembler instructions:

AMODE	DSECT	PRINT
CCW	DXD	PUNCH
CCW0	EJECT	PUSH
CCW1	END	RMODE
CNOP	ENTRY	REPRO
COM	EQU	SPACE
COPY	EXTRN	START
CSECT	ISEQ	TITLE
CXD	LTORG	USING
DC	OPSYN	WXTRN
DROP	ORG	MEXIT[1]
DS	POP	MNOTE[1]

[1] The MNOTE and MEXIT statements are not model statements; they are described in "Chapter 7. How to Prepare Macro Definitions."

- A variable symbol
- A combination of variable strings concatenated together

Operation code ICTL is not allowed inside a macro definition. The MACRO and MEND operation codes are not allowed in model statements; they are used only for delimiting macro definitions.

If the REPRO operation code is specified in a model statement, no substitution is performed for the variable symbols in the statement line following the REPRO statement. Variable symbols can be used alone or as part of a concatenated string to generate operation codes for:

- Any machine instruction, or
- Any assembler instruction listed above, except COPY, ISEQ, REPRO, and MEXIT.

The generated operation code must not be an operation code for the following (or their OPSYN equivalents):

- A macro instruction
- A conditional assembly instruction
- The following assembler instructions: COPY, ICTL, ISEQ, MACRO, MEND, MEXIT, and REPRO

OPERAND FIELD: The entries allowed in the operand field of a model statement, before generation, are given below:

Blank (if valid)
An ordinary symbol
A character string, combining alphameric and special characters (but not variable symbols)
A variable symbol
A combination of variable symbols and other character strings concatenated together

The allowable results of generation are a blank (if valid) and a character string that represents a valid assembler or machine instruction operand field.

Note: Variable symbols must not be used in the operand field of a COPY, ICTL, or ISEQ instruction.

REMARKS FIELD: The remarks field of a model statement can contain any combination of characters. No substitution is performed for variable symbols appearing in the remarks field. Only generated statements will be printed in the listing.

Note: One or more blanks must be used in a model statement to separate the name, operation, operand, and remarks fields from each other. Blanks cannot be generated between fields in order to create a complete assembler language statement. The exception to this rule is that a combined operand-remarks field can be generated with one or more blanks to separate the two fields.

SYMBOLIC PARAMETERS

Symbolic parameters allow you to pass values into the body of a macro definition from the calling macro instruction. You declare these parameters in the macro prototype statement. They can serve as points of substitution in the body of the macro definition and are replaced by the values assigned to them by the calling macro instruction.

By using symbolic parameters with meaningful names, you can indicate the purpose for which the parameters (or substituted values) are used.

Symbolic parameters must be valid variable symbols. A symbolic parameter consists of an ampersand followed by an alphabetic character and from 0 to 61 alphameric characters.

The following are valid symbolic parameters:

```
&READER     &LOOP2
&A23456     &N
&X4F2       &$4
```

The following are invalid symbolic parameters:

```
CARDAREA    (first character is not an ampersand)
&256B       (first character after ampersand is not a letter)
&BCD%34     (contains a special character other than initial
            ampersand)
&IN AREA    (contains a special character [the blank] other than
            initial ampersand)
```

Symbolic parameters have a local scope; that is, the value they are assigned only applies to the macro definition in which they have been declared.

The value of the parameter remains constant throughout the processing of the containing macro definition for every call on that definition.

Note: Symbolic parameters must not be multiply defined or identical to any other variable symbols within the given local scope. This applies to the system variable symbols described in "System Variable Symbols" in this chapter, and to local and global SET symbols described in "SET Symbols" on page 195.

The two kinds of symbolic parameters are:

- Positional parameters
- Keyword parameters

Each positional or keyword parameter used in the body of a macro definition must be declared in the prototype statement.

The following is an example of a macro definition with symbolic parameters.

Header		MACRO	
Prototype	&NAME	MOVE	&TO,&FROM
Model	&NAME	ST	2,SAVE
Model		L	2,&FROM
Model		ST	2,&TO
Model		L	2,SAVE
Trailer		MEND	

In the following macro instruction that calls the above macro, the characters HERE, FIELDA, and FIELDB of the MOVE macro instruction correspond to the symbolic parameters &NAME, &TO, and &FROM, respectively, of the MOVE prototype statement.

Name	Operation	Operand
HERE	MOVE	FIELDA,FIELDB

If the preceding macro instruction were used in a source program, the following assembler language statements would be generated:

Name	Operation	Operand
HERE	ST	2,SAVE
	L	2,FIELDB
	ST	2,FIELDA
	L	2,SAVE

POSITIONAL PARAMETERS

You should use a positional parameter in a macro definition if you want to change the value of the parameter each time you call the macro definition. This is because it is easier to supply the value for a positional parameter than for a keyword parameter. You only have to write the value you want the parameter to have in the proper position in the operand of the calling macro instruction.

For keyword parameters (described below), you must write the entire keyword and the equal sign that precedes the value to be passed. However, if you need a large number of parameters, you should use keyword parameters. The keywords make it easier to keep track of the individual values you must specify at each call by reminding you which parameters are being given values.

The general specifications for symbolic parameters, described in "Symbols" on page 21, also apply to positional parameters. Note that the specification for each positional parameter declared in the prototype statement definition must be a valid variable symbol. Values are assigned to the positional parameters by the corresponding positional operands specified in the macro instruction that calls the definition.

The general specifications for symbolic parameters also apply to positional parameters. Note that the specification for each positional parameter declared in the prototype statement definition must be a valid variable symbol. Values are assigned (see (1) in Figure 40 on page 162) to the positional parameters by the corresponding positional operands (see (2) in Figure 40) specified in the macro calls the definition.

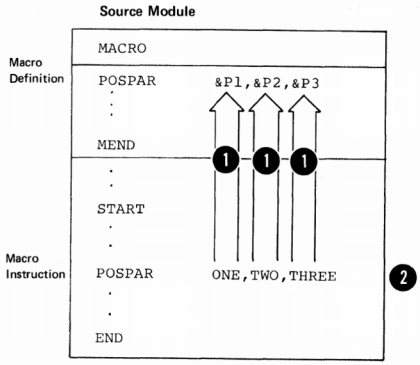


Figure 40. Positional Parameters

KEYWORD PARAMETERS

You should use a keyword parameter in a macro definition for a value that changes infrequently. By specifying a standard default value to be assigned to the keyword parameter, you can omit the corresponding keyword operand in the calling macro instruction.

Keyword parameters are also convenient because:

- You can specify the corresponding keyword operands in any order in the calling macro instruction.
- The keyword, repeated in the operand, reminds you which parameter is being given a value and for which purpose the parameter is being used.

The general specifications for symbolic parameters, described in "Symbols" on page 21, also apply to keyword parameters. Each keyword parameter must be in the format shown below:

```
where

  &KEYWORD is the variable symbol.
  = is an equals sign.
  DEFAULT is the standard value.
```

To give the above keyword parameter a value, you would code

```
KEYWORD=VALUE
```

for the keyword operand when you call the macro.

Note: A null character string can be specified as the standard value of a keyword parameter, and will be generated if the corresponding keyword operand is omitted.

The general specifications for symbolic parameters also apply to keyword parameters. Each keyword parameter must be in the format shown in Figure 41 on page 164.

The actual parameter must be a valid variable symbol (see (1) in Figure 41).

A value is assigned to a keyword parameter by the corresponding keyword operand (see (2) in Figure 41) through the name of the keyword as follows:

- If the corresponding keyword operand is omitted (see (3) in Figure 41), the standard value (see (4) in Figure 41) specified in the prototype statement becomes the value of the parameter for that call.
- If the corresponding keyword operand is specified (see (5) in Figure 41), the value after the equal sign overrides the standard value in the prototype and becomes the value of the parameter (see (6) in Figure 41) for that call.

COMBINING POSITIONAL AND KEYWORD PARAMETERS

By using positional and keyword parameters in a prototype statement, you combine the benefits of both. You can use positional parameters in a macro definition for passing values that change frequently, and keyword parameters for passing values that do not change often.

Positional and keyword parameters can be mixed freely in the macro prototype statement (see (1) in Figure 42 on page 165). The same applies to the positional and keyword operands of the macro instruction (see (2) in Figure 42). Note, however, that the order in which the positional parameters appear (see (3) in Figure 42) determines the order in which the positional operands must appear. Interspersed keyword parameters or operands (see (4) in Figure 42) do not affect this order.

SUBSCRIPTED SYMBOLIC PARAMETERS

Subscripted symbolic parameters must be coded in the format:

```
&PARAM(subscript)
```

where &PARAM is a variable symbol and the subscript is an arithmetic expression. The subscript can be any arithmetic expression allowed in the operand field of a SETA instruction (arithmetic expressions are discussed in "SETA—Set Arithmetic" on page 213. The arithmetic expression can contain subscripted

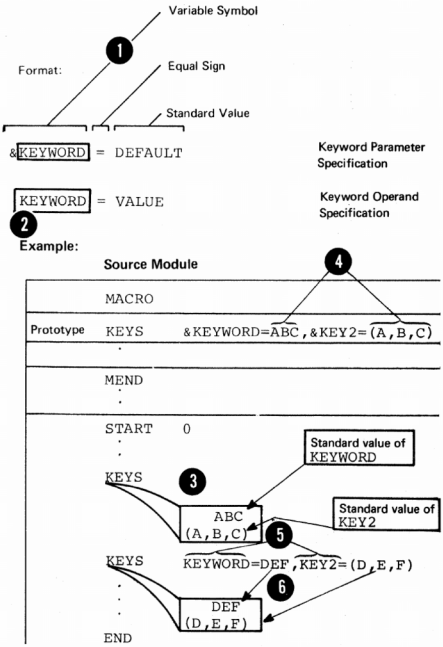


Figure 41. Keyword Parameters

variable symbols. Subscripts can be nested up to five levels of nesting.

The value of the subscript must be greater than or equal to one. The subscript indicates the position of the entry in the sublist that is specified as the value of the subscripted parameter (sublists as values in macro instruction operands are fully described in "Sublists in Operands" on page 185).

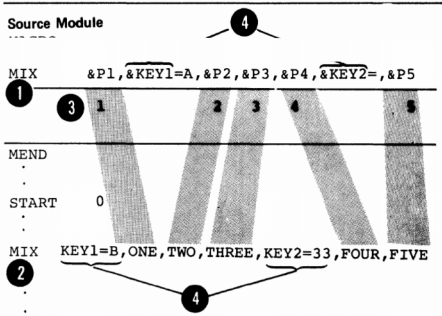


Figure 42. Combining Positional and Keyword Parameters

PROCESSING STATEMENTS

CONDITIONAL ASSEMBLY INSTRUCTIONS

Conditional assembly instructions allow you to determine at preassembly time the content of the generated statements and the sequence in which they are generated. The instructions and their functions are listed below:

Conditional Assembly	Function Performed
GBLA, GBLB, GBLC LCLA, LCLB, LCLC	Declaration of initial values of variable symbols (global and local SET symbols)
SETA, SETB, SETC	Assignment of values to variable symbols (SET symbols)
AIF	Conditional branch (based on logical test)
AGO	Unconditional branch
ANOP	Branch to next sequential instruction (no operation)
ACTR	Setting loop counter

Conditional assembly instructions can be used both inside macro definitions and in open code. They are described in "Chapter 9. How to Write Conditional Assembly Instructions."

INNER MACRO INSTRUCTIONS

Macro instructions can be nested inside macro definitions, allowing you to call other macros from within your own definition.

COPY INSTRUCTION

The COPY instruction, inside macro definitions, allows you to copy into the macro definition any sequence of statements allowed in the body of a macro definition. These statements become part of the body of the macro before macro processing takes place. You can also use the COPY instruction to copy complete macro definitions into a source module.

The specifications for the COPY instruction, which can also be used in open code, are described in "COPY—Copy Predefined Source Coding" on page 138.

MNOTE INSTRUCTION

You can use the MNOTE instruction to generate your own error messages or display intermediate values of variable symbols computed at preassembly time.

The MNOTE instruction can be used inside macro definitions or in open code, and its operation code can be created by substitution. The MNOTE instruction causes the generation of a message that is given a statement number in the printed listing.

The format of this instruction is:

Name	Operation	Operand
A sequence symbol or blank	MNOTE	Four options: n,'message' or ,'message' or *,'message' or ,'message'

The first two options are error messages; the last two are comments. The n stands for a severity code. The rules for specifying the contents of the severity code subfield are:

1. The severity code can be specified as any arithmetic expression allowed in the operand field of a SETA instruction. The expression must have a value in the range 0 through 255.

   Example:

   ```
     MNOTE  2,'ERROR IN SYNTAX'
   ```

   where the generated result is:

   ```
     2,ERROR IN SYNTAX
   ```

2. If the severity code is omitted, but the comma separating it from the message is present, the assembler assigns a default value of 1 as the severity code.

   Example:

   ```
     MNOTE  ,'ERROR, SEV 1'
   ```

   where the generated result is:

   ```
     ,ERROR, SEV 1
   ```

3. An asterisk in the severity code subfield causes the message and the asterisk to be generated as a comments statement.

```
MNOTE *,'NO ERROR'
```

where the generated result is:

```
*,NO ERROR
```

4. If the entire severity code subfield is omitted, including the comma separating it from the message, the assembler generates the message as a comments statement.

Example:

```
MNOTE  'NO ERROR'
```

where the generated result is:

```
NO ERROR
```

Notes:

1. An MNOTE instruction causes a message to be printed, if the current PRINT option is ON, even if the PRINT NOGEN option is specified.

2. The statement number of the message generated from an MNOTE instruction with a severity code is listed among any other error messages for the current source module. However, the message is printed only if the severity code specified is greater than or equal to the severity code 'nnn' in the assembler option, FLAG(nnn), specified when the assembler is invoked.

3. The statement number of the comments generated from an MNOTE instruction without a severity code is not listed among other error messages.

Any combination of up to 256 characters enclosed in single quotation marks can be specified in the message subfield. The rules that apply to this character string are as follows and are illustrated in Figure 43 on page 168.

- Variable symbols are allowed (see (1) in Figure 43).

  Note: Variable symbols can have a value that includes even the enclosing single quotation marks.

- Two ampersands (see (2) in Figure 43) and two single quotation marks (see (3) in Figure 43) are needed to generate an ampersand or a single quotation mark. If variable symbols have ampersands or single quotation marks as values, the values must be coded as two ampersands or two single quotation marks (see (4) in Figure 43).

Note: Any remarks for the MNOTE instruction statement must be separated by one or more blanks from the single quotation mark that ends the message.

MEXIT INSTRUCTION

The MEXIT instruction allows you to provide an exit for the assembler from any point in the body of a macro definition. The MEND instruction provides an exit only from the end of a macro definition (see "MEND—Macro Definition Trailer" on page 152 for details).

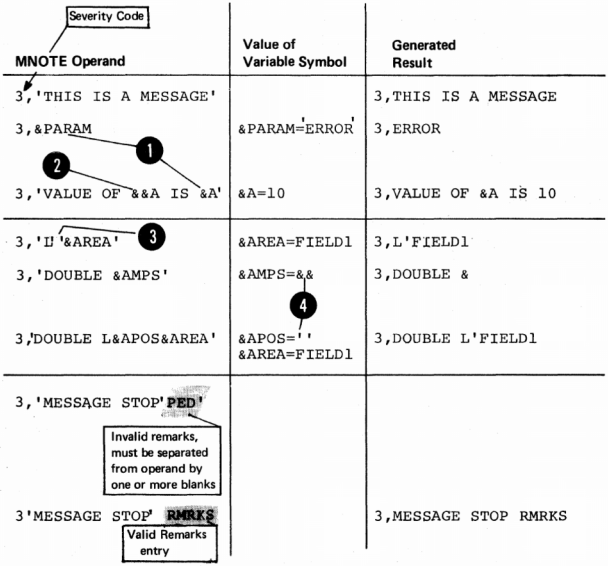


Figure 43. Rules for MNOTE Character Strings

The MEXIT instruction statement can be used only inside macro definitions. The format of this instruction is:

A sequence symbol or blank	MEXIT	Not required

The MEXIT instruction causes the assembler to exit from a macro definition to the next sequential instruction (see (1) in Figure 44 on page 170) after the macro instruction that calls the definition. (This also applies to nested macro instructions, which are described in "Nesting in Macro Definitions" on page 191.)

AREAD—ASSIGN CHARACTER STRING VALUE

You use the AREAD instruction to assign to a SETC symbol the character string value of a statement that is placed immediately after a macro instruction. AREAD functions in much the same way as symbolic parameters, but instead of supplying your input to macro processing as part of the macro instruction, you add the values in the form of whole 80-character input records that follow immediately after the macro instruction. Any number of successive statements can be read into the macro for processing.

The format of the AREAD instruction is:

Name	Operation	Operand
Any SETC symbol	AREAD	NOSTMT|NOPRINT

The SETC symbol in the name field may be subscripted. When the assembler encounters the AREAD statement during the processing of a macro instruction, it reads the source statement following the macro instruction and assigns an 80-character string to the SETC symbol in the name field. In the case of nested macros, it reads the statement following the outermost macro instruction.

Note: The AREAD instruction can only be used inside macro definitions.

If no operand is specified, the statement to be read by AREAD is printed in the listing and assigned a statement number. If NOSTMT is specified in the operand, the statement is printed, but not given any statement number. If NOPRINT is specified, the statement does not appear in the listing, and no statement number is assigned to it.

Repeated AREAD instruction statements read successive statements.

The records read by the AREAD instruction can be in code brought in with the COPY instruction, if the macro instruction appears in such code. If no more records exist in the code brought in by the COPY instruction, subsequent statements are read from the ordinary input stream.

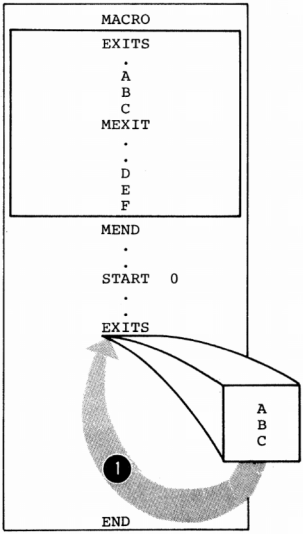


Figure 44. MEXIT Operation

For example:

```
         MACRO
         MAC1
         .
  &VAL   AREAD
         .
  &VAL1  AREAD
         .
         MEND
         CSECT
         .
         MAC1
  THIS IS THE STATEMENT TO BE PROCESSED FIRST
  THIS IS THE SECOND STATEMENT FOR THE SECOND AREAD
         .
         END
```

COMMENTS STATEMENTS

Ordinary comments statements allow you to make descriptive remarks about the generated output from a macro definition. Ordinary comments statements can be used in macro definitions and in open code.

A comments statement consists of an asterisk in the begin column followed by any character string. The comments statement is used by the assembler to generate an assembler language comments statement, just as other model statements are used by the assembler to generate assembler statements. No variable symbol substitution is performed.

INTERNAL MACRO COMMENTS STATEMENTS

You can also write internal macro comments in the body of a macro definition to describe the operations performed at preassembly time when the macro is processed.

Internal macro comments statements can be used only inside macro definitions. They may appear anywhere in a macro definition. An example of their correct use is given below:

```
Begin column (standard value):

Column 1 must contain a period (.).
Column 2 must contain an asterisk (*).
Column 3 may contain the start of any character string.
```

Note:
Internal macro comments will not be generated.

No values are substituted for any variable symbols that are specified in internal macro comments statements.

SYSTEM VARIABLE SYMBOLS

System variable symbols are variable symbols whose values are set by the assembler according to specific rules. You can use these symbols as points of substitution in model statements and conditional assembly instructions.

System variable symbols (&SYSDATE, &SYSPARM, and &SYSTIME) can be used as points of substitution both inside macro definitions and in open code. &SYSLOC gives you the name of the location counter in effect when the macro instruction appears. The remaining system variable symbols (&SYSECT, &SYSLOC, &SYSLIST, and &SYSNDX) can be used only inside macro definitions. All system variable symbols are subject to the same rules of concatenation and substitution as other variable symbols.

System variable symbols must not be used as symbolic parameters in the macro prototype statement. Also, they must not be declared as SET symbols.

The assembler assigns read-only values to system variable symbols; they cannot be changed by using the SETA, SETB, or SETC instruction.

SCOPE OF SYSTEM VARIABLE SYMBOLS: The system variable symbols (&SYSDATE, &SYSPARM, and &SYSTIME) have a global scope. This means that they are assigned a read-only value for an entire source module, a value that is the same throughout open code and inside any macro definitions called.

The system variable symbols (&SYSECT, &SYSLOC, &SYSLIST, and &SYSNDX) have a local scope. They are assigned a read-only

value each time a macro is called, and have that value only within the expansion of the called macro.

&SYSDATE—Macro Instruction Date

You can use &SYSDATE to obtain the date on which your source module is assembled.

&SYSDATE is assigned a read-only value of the following format:

```
mm/dd/yy (8-character string)

where:

  mm gives the month.
  dd gives the day.
  yy gives the year.

Example:

  11/25/82

Note:
This date corresponds to the date printed in the page
heading of listings and remains constant for each assembly.
```

Note: The value of the type attribute of &SYSDATE (T'&SYSDATE) is always U, and the value of the count attribute (K'&SYSDATE) is always 8.

&SYSECT—Current Control Section

You can use &SYSECT in a macro definition to generate the name of the current control section. The current control section is the control section in which the macro instruction that calls the definition appears.

The local system variable symbol &SYSECT is assigned a read-only value each time a macro definition is called.

The value assigned is the symbol that represents the name of the current control section from which the macro definition is called. Note that it is the control section in effect when the macro is called. A control section that has been initiated or continued by substitution does not affect the value of &SYSECT for the expansion of the current macro. However, it does affect &SYSECT for a subsequent macro call. Nested macros cause the assembler to assign a value to &SYSECT that depends on the control section in force inside the outer macro when the inner macro is called.

Notes:

1. The control section whose name is assigned to &SYSECT can be defined by a START, CSECT, DSECT, or COM instruction.

2. The value of the type attribute of &SYSECT (T'&SYSECT) is always U, and the value of the count attribute (K'&SYSECT) is equal to the number of characters assigned as a value to &SYSECT.

3. Throughout the use of a macro definition, the value of &SYSECT may be considered a constant, independent of any CSECT or DSECT statements or inner macro instructions in that definition.

The next example illustrates these rules. In it, statement 8 is the last CSECT, DSECT, or START statement processed before statement 9 is processed. Therefore, &SYSECT is assigned the

6.

Statement 3 is the last CSECT, DSECT, or START statement processed before statement 4 is processed. Therefore, &SYSECT is assigned the value CSOUT1 for macro instruction INNER in statement 4. CSOUT1 is substituted for &SYSECT when it appears in statement 2.

Statement 1 is used to generate a CSECT statement for statement 4. This is the last CSECT, DSECT, or START statement that appears before statement 5. Therefore, &SYSECT is assigned the value INA for macro instruction INNER in statement 5. INA is substituted for &SYSECT when it appears in statement 2.

	Name	Operation	Operand
		MACRO	
		INNER	&INCSECT
1	&INCSECT	CSECT	
2		DC	A(&SYSECT)
		MEND	
		MACRO	
		OUTER1	
3	CSOUT1	CSECT	
		DS	100C
4		INNER	INA
5		INNER	INB
6		DC	A(&SYSECT)
		MEND	
		MACRO	
		OUTER2	
7		DC	A(&SYSECT)
		MEND	
8	MAINPROG	CSECT	
		DS	200C
9		OUTER1	
10		OUTER2	
	MAINPROG	CSECT	
		DS	200C
	CSOUT1	CSECT	
		DS	100C
	INA	CSECT	
		DC	A(CSOUT1)
	INB	CSECT	
		DC	A(INA)
		DC	A(MAINPROG)
		DC	A(INB)

Statement 1 is used to generate a CSECT statement for statement 5. This is the last CSECT, DSECT, or START statement that appears before statement 10. Therefore, &SYSECT is assigned the value INB for macro instruction OUTER2 in statement 10. INB is substituted for &SYSECT when it appears in statement 7.

&SYSLIST—Macro Instruction Operand

You can use &SYSLIST instead of a positional parameter inside a macro definition; for example, as a point of substitution. By varying the subscripts attached to &SYSLIST, you can refer to any sublist entry in a macro call, or any positional operands in a macro call. You can also refer to positional operands for

which no corresponding positional parameter is specified in the macro prototype statement.

The local system variable symbol &SYSLIST is assigned a read-only value each time a macro definition is called. &SYSLIST refers to the complete list of positional operands specified in a macro instruction. &SYSLIST does not refer to keyword operands. However, &SYSLIST cannot be specified as &SYSLIST alone. One of the two following forms must be used as a point of substitution:

1. &SYSLIST(n) may be used to refer to the nth positional operand

2. If the nth operand is a sublist, then &SYSLIST(n,m) may be used to refer to the mth operand in the sublist.

The subscripts n and m can be any arithmetic expression allowed in the operand of a SETA instruction. The subscript n must be greater than or equal to 0. The subscript m must be greater than or equal to 1.

When referring to multilevel (nested) sublists in operands of macro instructions, reference to elements of inner sublists can be made using the appropriate number of subscripts for &SYSLIST.

The examples below show the values assigned to &SYSLIST according to the value of its subscripts n and m.

Macro instruction:

	Point of Substitution in Macro Definition	Value Substituted
	&SYSLIST(2)	TWO
	&SYSLIST(3,2)	4
(1)	&SYSLIST(4)	Null
(2)	&SYSLIST(9)	Null
(3)	&SYSLIST(3,3)	Null
(4)	&SYSLIST(3,5)	Null
(5)	&SYSLIST(2,1)	TWO
	&SYSLIST(2,2)	Null
(6)	&SYSLIST(0)	NAME
	&SYSLIST(3)	(3,4,,6)

Notes:

(1) If the position indicated by n refers to an omitted
(2) operand, or refers past the end of the list of positional operands specified, the null character string is substituted for &SYSLIST(n).
(3) If the position (in a sublist) indicated by the second subscript, m, refers to an omitted entry,
(4) or refers past the end of the list of entries specified in the sublist referred to by the first subscript, n, the null character string is substituted for &SYSLIST(n,m).
(5) Further, if the nth positional operand is not a sublist, &SYSLIST(n,1) refers to the operand but &SYSLIST(n,m), where m is greater than 1, will cause the null character string to be substituted.
(6) If the value of subscript n is 0, then &SYSLIST(n) is assigned the value specified in the name field of the macro instruction, except when it is a sequence symbol.

Attribute references can be made to the previously described forms of &SYSLIST. The attributes will be the attributes inherent in the positional operands or sublist entries to which you refer. However, the number attribute of &SYSLIST (N'&SYSLIST) is different from the number attribute described in "Data Attributes." One of two forms (N'&SYSLIST or N'&SYSLIST(n)) can be used for the number attribute:

- To indicate the number of positional operands specified in a call, you use the form N'&SYSLIST.
- To indicate the number of sublist entries that have been specified in a positional operand, you use the form N'&SYSLIST(n).

Notes:

1. For N'&SYSLIST, positional operands are counted if specifically omitted by specifying the comma that would normally have followed the operand.

2. For N'&SYSLIST(n), sublist entries are counted if specifically omitted by specifying the comma that would normally have followed the entry.

3. If the operand indicated by n is not a sublist, N'&SYSLIST(n) is 1. If it is omitted, N'&SYSLIST(n) is 0.

Examples:

Macro Instruction		N'&SYSLIST
MACLST	1,2,3,4	4
MACLST	A,B,,D,E	5
MACLST	,A,B,C,D	5
MACLST	(A,B,C),(D,E,F)	2
MACLST		0
MACLST	KEY1=A,KEY2=B	0
MACLST	A,B,KEY1=C	2
		N'&SYSLIST(2)
MACSUB	A,(1,2,3,4,5),B	5
MACSUB	A,(1,,3,,5),B	5
MACSUB	A,(,2,3,4,5),B	5
MACSUB	A,B,C	1
MACSUB	A,,C	0
MACSUB	A,KEY=(A,B,C)	0
MACSUB		0

&SYSNDX—Macro Instruction Index

You can attach &SYSNDX to the end of a symbol inside a macro definition to generate a unique suffix for that symbol each time you call the definition. Although the same symbol is generated by two or more calls to the same definition, the suffix provided by &SYSNDX produces two or more unique symbols. Thus you avoid an error being flagged for multiply defined symbols.

The local system variable symbol &SYSNDX is assigned a read-only value each time a macro definition is called from a source module.

The value assigned to &SYSNDX is a 4-digit number, starting at 0001 for the first macro called by a program. It is incremented by one for each subsequent macro call (including nested macro calls).

Notes:

1. &SYSNDX does not generate a valid symbol, and it must:
   - Follow the symbol to which it is concatenated
   - Be concatenated to a symbol containing 4 characters or less
2. The value of the type attribute of &SYSNDX (T'&SYSNDX) is always N, and the value of the count attribute (K'&SYSNDX) is always 4.

The following example illustrates the use of &SYSNDX. It is assumed that the first macro instruction processed, OUTER1, is the 106th macro instruction processed by the assembler.

	Name	Operation	Operand
		GBLC	&NDXNUM
1	A&SYSNDX	SR	2,5
		CR	2,5
2		BE	B&NDXNUM
3		B	A&SYSNDX
		MEND	
		MACRO	
	&NAME	OUTER1	
		GBLC	&NDXNUM
4	&NDXNUM	SETC	'&SYSNDX'
	&NAME	SR	2,4
		AR	2,6
5		INNER1	
6	B&SYSNDX	S	2,=F'1000'
		MEND	
7	ALPHA	OUTER1	
8	BETA	OUTER1	
	ALPHA	SR	2,4
		AR	2,6
	A0107	SR	2,5
		CR	2,5
		BE	B0106
		B	A0107
	B0106	S	2,=F'1000'
	BETA	SR	2,4
		AR	2,6
	A109	SR	2,5
		CR	2,5
		BE	B0108
		B	A0109
	B0108	S	2,=F'1000'

Statement 7 is the 106th macro instruction processed. Therefore, &SYSNDX is assigned the number 0106 for that macro instruction. The number 0106 is substituted for &SYSNDX when it is used in statements 4 and 6. Statement 4 is used to assign the character value 0106 to the SETC symbol &NDXNUM. Statement 6 is used to create the unique name B0106.

Statement 5 is the 107th macro instruction processed. Therefore, &SYSNDX is assigned the number 0107 for that macro instruction. The number 0107 is substituted for &SYSNDX when it is used in statements 1 and 3. The number 0106 is substituted for the global SETC symbol &NDXNUM in statement 2.

Statement 8 is the 108th macro instruction processed. Therefore, each occurrence of &SYSNDX is replaced by the number 0108. For example, statement 6 is used to create the unique name B0108.

When statement 5 is used to process the 108th macro instruction, statement 5 becomes the 109th macro instruction processed. Therefore, each occurrence of &SYSNDX is replaced by the number 0109. For example, statement 1 is used to create the unique name A0109.

&SYSPARM—Source Module Communication

You can use &SYSPARM to communicate with an assembler source module through job control language (JCL). Through &SYSPARM, you pass a character string into the source module to be assembled from a JCL statement, or from a program that dynamically invokes the assembler. Thus, you can set a character value from outside a source module and then examine it

as part of the source module at preassembly time, during conditional assembly processing.

The global system variable symbol &SYSPARM is assigned a read-only value in a JCL statement or in a field set up by a program that dynamically invokes the assembler. It is treated as a global SETC symbol in a source module except that its value cannot be changed.

Notes:

1. The largest value that &SYSPARM can hold when you code your own procedure is 91 characters, which can be specified by an invoking program. However, if the PARM field of the EXEC statement is used to specify its value, the PARM field restrictions reduce its maximum possible length.

   Note: Under CMS, the option line of the ASSEMBLE command cannot exceed 100 characters, thus limiting the number of characters you can specify for &SYSPARM.

2. No values are substituted for variable symbols in the specified value; however, double ampersands must be used to represent single ampersands in the value.

   Note: Since CMS does not strip ampersands from the variable symbol, you need not specify double ampersands for CMS.

3. Two single quotation marks are needed to represent a single quotation mark because the entire PARM field specification is enclosed in single quotation marks.

   Note: Since CMS does not strip single quotation marks from the variable symbol, you need not specify two single quotation marks for CMS.

4. If SYSPARM is not specified in a JCL statement outside the source module, &SYSPARM is assigned a default value of the null character string.

5. The value of the type attribute of &SYSPARM (T'&SYSPARM) is always U, while the value of the count attribute (K'&SYSPARM) is the number of characters specified for SYSPARM in a JCL statement, or in a field set up by a program that dynamically invokes the assembler. Two single quotation marks and two ampersands count as one character.

6. CMS parses the command line, breaking the input into 8-character tokens; therefore, the SYSPARM option field under CMS is limited to an 8-character field. If you want to enter larger fields, or if you want to enter parentheses or embedded blanks, you must enter the special symbol "?" (the question mark symbol) in the option field. When CMS encounters this symbol in the command line, it will prompt you with the message ENTER SYSPARM:, after which you can enter any characters you want up to the option line limit of 100 characters. The following code is an example of how to use the ? symbol in the SYSPARM field:

   ```
   assemble test (object deck sysparm(?)
   ENTER SYSPARM:
   &&am,'bo).fy
   .
   .
   .
   R;
   ```

7. If &SYSPARM is not specified when you invoke the assembler, the system parameter is assigned the value that was specified when the assembler was generated (added to your system).

&SYSTIME—Macro Instruction Time

You can use &SYSTIME to obtain the time at which your source module is assembled.

The global system variable symbol &SYSTIME is assigned a read-only value in the following format:

```
  hh.mm (5-character string)

where:

  hh gives the hours.
  mm gives the minutes.

Example:  22.15


Note:
22.15 corresponds to the time printed in the page
heading of listings, and remains constant for each assembly.
```

Notes:

1. The value of the type attribute of &SYSTIME (T'&SYSTIME) is always U, and the value of the count attribute (K'&SYSTIME) is always 5.
2. For systems without the internal time feature, &SYSTIME is a 5-character string of blanks.

&SYSLOC—Location Counter Name

You can use &SYSLOC in a macro definition to generate the name of the location counter currently in effect. If you have not coded a LOCTR instruction between the macro instruction and the preceding START, CSECT, DSECT, or COM instruction, the value of &SYSLOC is the same as the value of &SYSECT.

The assembler assigns to the system variable symbol &SYSLOC a local read-only value each time a macro definition containing it is called. The value assigned is the symbol representing the name of the location counter in use at the point where the macro is called.

&SYSLOC can only be used in macro definitions.

Notes:

1. The value of the type attribute of &SYSLOC (T'&SYSLOC) is always U, and the value of the count attribute (K'&SYSLOC) is equal to the number of characters assigned as a value to &SYSLOC.
2. Throughout the use of a macro definition, the value of &SYSLOC may be considered a constant.

CHAPTER 8. HOW TO WRITE MACRO INSTRUCTIONS

This chapter describes macro instructions: where they can be used and how they are specified, including details on the name, operation, and operand entries, and what will be generated as a result of that macro call.

The macro instruction provides the assembler with:

- The name of the macro definition to be processed
- The information or values to be passed to the macro definition

This information is the input to a macro definition. The assembler uses the information either in processing the macro definition, or for substituting values into a model statement in the definition.

The output from a macro definition, called by a macro instruction, can be:

- A sequence of statements generated from the model statements of the macro for further processing at assembly time
- Values assigned to global SET symbols

These values can be used in other macro definitions and in open code (see "SET Symbols" on page 195).

WHERE MACRO INSTRUCTIONS CAN APPEAR

A macro instruction can be written anywhere in your program, if the assembler finds its definition either in a macro library or in the source module before it finds the macro instruction. However, the statements generated from the called macro definition must be valid assembler language instructions and allowed where the calling macro instruction appears. A macro instruction can be nested inside a macro definition (see "Nesting in Macro Definitions" on page 191).

MACRO INSTRUCTION FORMAT

The format of a macro instruction is:

Name	Operation	Operand
Any symbol or blank	Symbolic operation code	0 through 240 operands separated by commas

If no operands are specified in the operand field and if the absence of the operand entry is indicated by a comma preceded and followed by one or more blanks, remarks are allowed.

The entries in the name, operation, and operand fields correspond to entries in the prototype statement of the called macro definition (see "ENTRY—Identify Entry-Point Symbol" on page 66).

ALTERNATIVE WAYS OF CODING A MACRO INSTRUCTION

A macro instruction can be specified in one of the three following ways:

- The normal way, with the operands preceding any remarks

- The alternate way, allowing remarks for each operand
- A combination of the first two ways

Notes:

1. Any number of continuation lines are allowed. However, each continuation line must be indicated by a nonblank character in the column after the end column of the previous statement line (see "Continuation Lines" on page 10).

2. Operands on continuation lines must begin in the continue column (column 16), or the assembler assumes that any lines that follow contain remarks.

   If any entries are made in the columns before the continue column in continuation lines, the assembler issues an error message and the whole statement is not processed.

3. One or more blanks must separate the operand from the remarks.

4. A comma after an operand indicates more operands will follow.

5. The last operand requires no comma following it, but using a comma will not cause an error.

NAME ENTRY

You can use the name entry of a macro instruction:

- To generate an assembly-time label for a machine or assembler instruction, or
- To provide a conditional assembly label (see "Sequence Symbols" on page 208) so that you can branch to the macro instruction at preassembly time if you want the called macro definition expanded.

The name entry of a macro instruction can be:

- An ordinary symbol, such as HERE
- A variable symbol, such as &A
- A character string in which a variable symbol is concatenated to other characters, such as HERE.&A
- A blank
- A sequence symbol, which is never generated, such as .SEQ

OPERATION ENTRY

The symbolic operation code you specify identifies the macro definition you wish the assembler to process.

The operation entry for a macro instruction must be a valid symbol that is identical to the symbolic operation code specified in the prototype statement of the macro definition called.

Note: If a source macro definition with the same operation code as a library macro definition is called, the assembler processes the source macro definition.

You can code a variable symbol in the operation field of a macro instruction if the value of the variable symbol specifies the operation code of a library or source macro that has been previously defined. Thus, if MAC1 has been defined as a macro, you can use the following statements to call it:

```
&CALL   SETC  'MAC1'
        &CALL
```

OPERAND ENTRY

You can use the operand entry of a macro instruction to pass values into the called macro definition. These values can be passed through:

- The symbolic parameters you have specified in the macro prototype, or
- The system variable symbol &SYSLIST if it is specified in the body of the macro definition (see "&SYSLIST—Macro Instruction Operand" on page 173).

The two types of operands allowed in a macro instruction are the positional and keyword operands. You can specify a sublist with multiple values in both types of operands. Special rules for the various values you can specify in operands are also given below.

Positional Operands

You can use a positional operand to pass a value into a macro definition through the corresponding positional parameter declared for the definition. You should declare a positional parameter in a macro definition when you wish to change the value passed at every call to that macro definition.

You can also use a positional operand to pass a value to the system variable symbol &SYSLIST. If &SYSLIST, with the appropriate subscripts, is specified in a macro definition, you do not need to declare positional parameters in the prototype statement of the macro definition. You can thus use &SYSLIST to refer to any positional operand. This allows you to vary the number of operands you specify each time you call the same macro definition.

The positional operands of a macro instruction must be specified in the same order as the positional parameters declared in the called macro definition.

Each positional operand constitutes a character string. It is this character string that is the value passed through a positional parameter into a macro definition.

Notes:

1. An omitted operand has null character value.
2. Each positional operand can be up to 255 characters long.

The following are examples of macro instructions with positional operands:

```
MACCALL   VALUE,9,8
MACCALL   &A,'QUOTED STRING'
MACCALL   EXPR+2,,SYMBOL
MACCALL   (A,B,C,D,E),(1,2,3,4)
```

The following shows what happens when the number of positional operands in the macro instruction is equal to or differs from the number of positional parameters declared in the prototype statement of the called macro definition:

equal	Valid, if operands are correctly specified.
greater than	Meaningless, unless &SYSLIST is specified in definition to refer to excess operands.
less than	Omitted operands give null character values to corresponding parameters (or &SYSLIST specification).

Keyword Operands

You can use a keyword operand to pass a value through a keyword parameter into a macro definition. The values you specify in keyword operands override the default values assigned to the keyword parameters. The default value should be a value you use frequently. Thus, you avoid having to write this value every time you code the calling macro instruction.

When you need to change the default value, you must use the corresponding keyword operand in the macro instruction. The keyword can indicate the purpose for which the passed value is used.

Any keyword operand specified in a macro instruction must correspond to a keyword parameter in the macro definition called. However, keyword operands do not have to be specified in any particular order.

A keyword operand must be coded in the format shown below:

```
KEYWORD=VALUE
```

where

KEYWORD has up to 62 characters without ampersand.
= is an equal sign.
VALUE can be up to 255 characters.

The corresponding keyword parameter in the called macro definition is specified as:

```
&KEYWORD=DEFAULT
```

If a keyword operand is specified, its value overrides the default value specified for the corresponding keyword parameter.

The following examples of macro instructions have keyword operands:

```
MACKEY   KEYWORD=(A,B,C,D,E)
MACKEY   KEY1=1,KEY2=2,KEY3=3
MACKEY   KEY3=2000,KEY1=0,KEYWORD=HALLO
```

To summarize the relationship of keyword operands to keyword parameters:

- The keyword of the operand corresponds (see (1) in Figure 45 on page 184) to a keyword parameter. The value in the operand overrides the default value of the parameter.
- If the keyword operand is not specified (see (2) in Figure 45), the default value of the parameter is used.
- If the keyword of the operand does not correspond (see (3) in Figure 45) to any keyword parameter, the assembler issues an error message, but the macro is generated using the default values of the other parameters.

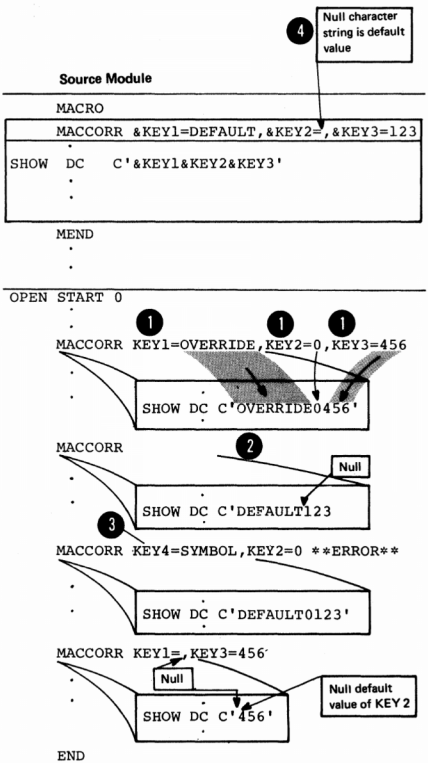


Figure 45. Relationship between Keyword Operands and Keyword Parameters and Their Assigned Values

Note: The default value specified for a keyword parameter can be the null character string (see (4) in Figure 45). The null character string is a character string with a length of zero; it is not a blank, because a blank occupies one character position.

Combining Positional and Keyword Operands

You can use positional and keyword operands in the same macro instruction: Use a positional operand for a value that you change often, and a keyword operand for a value that you change infrequently.

Positional and keyword operands can be combined in the macro instruction operand field. However, the positional operands must be in the same order as the corresponding positional parameter in the macro prototype statement.

Note: The system variable symbol &SYSLIST(n) refers only to the positional operands in a macro instruction.

SUBLISTS IN OPERANDS

You can use a sublist in a positional or keyword operand to specify several values. A sublist is one or more entries separated by commas and enclosed in parentheses. Each entry is a value to which you can refer in a macro definition by coding:

- The corresponding symbolic parameter with an appropriate subscript, or
- The system variable symbol &SYSLIST with appropriate subscripts, the first of which refers to the positional operand, and the second to the sublist entry in the operand.

  &SYSLIST can refer only to sublists in positional operands.

Figure 46 on page 186 illustrates that the value specified in a positional or keyword operand can be a sublist.

A symbolic parameter can refer to the entire sublist (see (1) in Figure 46), or to an individual entry of the sublist. To refer to an individual entry, the symbolic parameter (see (2) in Figure 46) must have a subscript whose value indicates the position (see (3) in Figure 46) of the entry in the sublist. The subscript must have a value greater than or equal to 1.

A sublist, including the enclosing parentheses, must not contain more than 255 characters. It consists of one or more entries separated by commas and enclosed in parentheses; for example, (A,B,C,D,E). () is a valid sublist with the null character string as the only entry.

The following list shows the relationship between subscripted parameters and sublist entries if:

1. A sublist entry is omitted: &PAR(3) (1,2,,4)
2. The subscript refers past the end of the sublist: &PAR(5) (1,2,3,4)
3. The value of the operand is not a sublist:
   - &PAR A
   - &PAR(1) A
   - &PAR(2) A
4. The parameter is not subscripted: &PAR ()

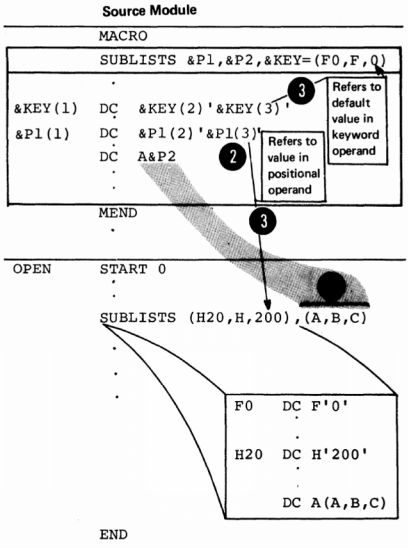


Figure 46. Sublists in Operands

Figure 47 on page 187 shows the relationship between subscripted parameters and sublist entries if:

- A sublist entry is omitted (see (1) in Figure 47).
- The subscript refers past the end of the sublist (see (2) in Figure 47).
- The value of the operand is not a sublist (see (3) in Figure 47).
- The parameter is not subscripted (see (4) in Figure 47).

Note: The system variable symbol, &SYSLIST(n,m), can also refer to sublist entries, but only if the sublist is specified in a positional operand.

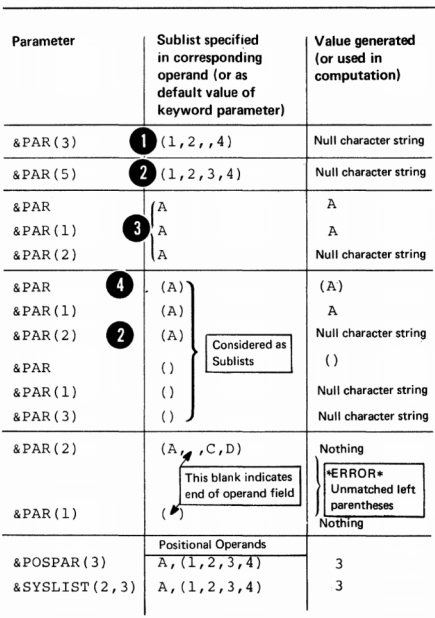


Figure 47. Relationship between Subscripted Parameters and Sublist Entries

Multilevel Sublists

You can specify multilevel sublists (sublists within sublists) in macro operands. The depth of this nesting is limited only by the constraint that the total operand length must not exceed 255 characters. Inner elements of the sublists are referenced using additional subscripts on symbolic parameters or on &SYSLIST.

N'&SYSLIST with an n-element subscript array gives the number of operands in the indicated n-th level sublist. The number attribute (N') and a parameter name with an n-element subscript array gives the number of operands in the indicated (n+1)th level sublist.

For example, if &P is the first positional parameter and the value assigned in a macro instruction is (A,(B,(C)),D) then:

```
&P              =&SYSLIST(1)          =(A,(B,(C)),D)
&P(1)           =&SYSLIST(1,1)        = A
&P(2)           =&SYSLIST(1,2)        =   (B,(C))
&P(2,1)         =&SYSLIST(1,2,1)      =    B
&P(2,2)         =&SYSLIST(1,2,2)      =      (C)
&P(2,2,1)       =&SYSLIST(1,2,2,1)    =       C
&P(2,2,2)       =&SYSLIST(1,2,2,2)    =null
&P(3)           =&SYSLIST(1,3)        =             D

N'&P(2,2)       =N'&SYSLIST(1,2,2)    =1
N'&P(2)         =N'&SYSLIST(1,2)      =2
N'&P(3)         =N'&SYSLIST(1,3)      =1
N'&P            =N'&SYSLIST(1)        =3
```

Passing Sublists to Inner Macro Instructions

You can pass a suboperand of an outer macro instruction sublist as a sublist to an inner macro instruction.

VALUES IN OPERANDS

You can use a macro instruction operand to pass a value into the called macro definition. The two types of value you can pass are:

- Explicit values or the actual character strings you specify in the operand
- Implicit values, or the attributes inherent in the data represented by the explicit values

The explicit value specified in a macro instruction operand is a character string that can contain one or more variable symbols.

The character string must not be greater than 255 characters after substitution of values for any variable symbols. This includes a character string that constitutes a sublist.

The character string values, including sublist entries, in the operands are assigned to the corresponding parameters declared in the prototype statement of the called macro definition. A sublist entry is assigned to the corresponding subscripted parameter.

Omitted Operands

When a keyword operand is omitted, the default value specified for the corresponding keyword parameter is the value assigned to the parameter. When a positional operand or sublist entry is omitted, the null character string is assigned to the parameter.

Notes:

1. Blanks appearing between commas do not signify an omitted positional operand or an omitted sublist entry; they indicate the end of the operand field.
2. Commas indicate omission of positional operands; no comma is needed to indicate omission of the last positional operand.

The following example shows a macro instruction preceded by its corresponding prototype statement. The macro instruction operands that correspond to the third and sixth operands of the prototype statement are omitted in this example.

Name	Operation	Operand
	EXAMPLE EXAMPLE	&A,&B,&C,&D,&E,&F 17,*+4,,AREA,FIELD(6)

Special Characters

Any of the 256 characters of the System/370 character set can appear in the value of a macro instruction operand (or sublist entry). However, the following characters require special consideration:

AMPERSANDS: A single ampersand indicates the presence of a variable symbol. The assembler substitutes the value of the variable symbol into the character string specified in a macro instruction operand. The resultant string is then the value passed into the macro definition. If the variable symbol is undefined, an error message is issued.

Double ampersands must be specified if they are to be passed to the macro definition.

Examples:

```
&VAR
&A+&B+3+&C*10
'&MESSAGE'
&&REGISTER
```

SINGLE QUOTATION MARKS: A single quotation mark is used:

- To indicate the beginning and end of a quoted string, and
- In a length attribute notation that is not within a quoted string.

Examples:

```
'QUOTED STRING'
L'SYMBOL
```

QUOTED STRINGS: A quoted string is any sequence of characters that begins and ends with a single quotation mark (compare with conditional assembly character expressions described in "Character (SETC) Expressions").

Two single quotation marks must be specified inside each quoted string. This includes substituted single quotation marks.

Macro instruction operands can have values that include one or more quoted strings. Each quoted string can be separated from the following quoted string by one or more characters, and each must contain an even number of single quotation marks.

Examples:

```
''
'L''SYMBOL'
'QUOTE1'AND'QUOTE2'
```

LENGTH ATTRIBUTE NOTATION: In macro instruction operand values, the length attribute notation with ordinary symbols can be used outside of quoted strings, if the length attribute notation is preceded by any special character except the ampersand.

Example:

```
L'SYMBOL,10+L'AREA*L'FIELD
```

PARENTHESES: In macro instruction operand values, there must be an equal number of left and right parentheses. They must be paired, that is, to each left parenthesis belongs a following right parenthesis at the same level of nesting. An unpaired (single) left or right parenthesis can appear only in a quoted string.

Examples:

```
(PAIRED PARENTHESES)
()
(A(B)C)D(E)
(IN'('STRING)
```

BLANKS: One or more blanks outside a quoted string indicates the end of the entire operand field of a macro instruction. Thus blanks should only be used inside quoted strings.

Example:

```
'BLANKS ALLOWED'
```

COMMAS: A comma outside a quoted string indicates the end of an operand value or sublist entry. Commas that do not delimit values can appear inside quoted strings or paired parentheses that do not enclose sublists.

Examples:

```
A,B,C,D
(1,2)3'5,6'
```

EQUAL SIGNS: An equal sign can appear in the value of a macro instruction operand or sublist entry:

- As the first character,
- Inside quoted strings,
- Between paired parentheses,
- In a keyword operand, or
- In a positional operand, provided the parameter does not resemble a keyword operand.

The assembler issues a warning message for a positional operand containing an equal sign, if the operand resembles a keyword operand. Thus, if we assume that the following is the prototype of a macro definition:

```
MAC1  &F
```

the following macro instruction would generate a warning message:

```
MAC1  K=L  (K is a valid keyword)
```

while the following macro instruction would not:

```
MAC1  2+2=4  (2+2 is not a valid keyword)
```

Examples:

```
=H'201'
A'='B
C(A=B)
2X=B
KEY=A=B
```

PERIODS: A period (.) can be used in the value of an operand or sublist entry. It will be passed as a period. However, if it is used immediately after a variable symbol, it becomes a

concatenation character. Then, two periods are required if one is to be passed as a character.

Examples:

```
3.4
&A.1
&A..1
```

NESTING IN MACRO DEFINITIONS

A nested macro instruction is a macro instruction you specify as one of the statements in the body of a macro definition. This allows you to call for the expansion of a macro definition from within another macro definition.

INNER AND OUTER MACRO INSTRUCTIONS

Any macro instruction you write in the open code of a source module is an outer macro instruction or call. Any macro instruction that appears within a macro definition is an inner macro instruction or call.

LEVELS OF NESTING

The code generated by a macro definition called by an inner macro call is nested inside the code generated by the macro definition that contains the inner macro call. In the macro definition called by an inner macro call, you can include a macro call to another macro definition. Thus, you can nest macro calls at different levels.

The zero level includes outer macro calls, calls that appear in open code; the first level of nesting includes inner macro calls that appear inside macro definitions called from the zero level; the second level of nesting includes inner macro calls inside macro definitions that are called from the first level, etc.

Recursion

You can also call a macro definition recursively; that is, you can write macro instructions inside macro definitions that are calls to the containing definition. This allows you to define macros to process recursive functions.

GENERAL RULES AND RESTRICTIONS

Macro instruction statements can be written inside macro definitions. Values are substituted in the same way as they are for the model statements of the containing macro definition. The assembler processes the called macro definition, passing to it the operand values (after substitution) from the inner macro instruction. In addition to the operand values described in "Values in Operands" on page 188, nested macro calls can specify values that include (see Figure 48 on page 192):

- Any of the symbolic parameters (see (1) in Figure 48) specified in the prototype statement of the containing macro definition
- Any SET symbols (see (2) in Figure 48) declared in the containing macro definition
- Any of the system variable symbols such as &SYSDATE, &SYSTIME, etc. (see (3) in Figure 48).

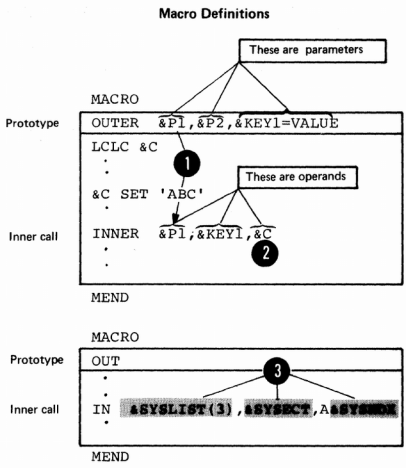


Figure 48. Values in Nested Macro Calls

The number of nesting levels permitted depends on the complexity and size of the macros at the different levels; that is, the number of operands specified, the number of local and global SET symbols declared, and the number of sequence symbols used.

Exits taken from the different levels of nesting when a MEXIT or MEND instruction is encountered are as follows:

1. From the expansion of a macro definition called by an inner macro call, an exit is taken to the next sequential instruction that appears after the inner macro call in the containing macro definition.

2. From the expansion of a macro definition called by an outer macro, an exit is taken to the next sequential instruction that appears after the outer macro call in the open code of a source module.

PASSING VALUES THROUGH NESTING LEVELS

The value contained in an outer macro instruction operand can be passed through one or more levels of nesting (see Figure 49 on page 194). However, the value specified (see (1) in Figure 49) in the inner macro instruction operand must be identical to the corresponding symbolic parameter (see (2) in Figure 49) declared in the prototype of the containing macro definition.

Thus, a sublist can be passed (see (3) in Figure 49) and referred to (see (4) in Figure 49) as a sublist in the macro definition called by the inner macro call. Also, any symbol (see (5) in Figure 49) that is passed will carry its inherent attribute values through the nesting levels.

If inner macro calls at each level are specified with symbolic parameters as operand values, values can be passed from open code through several levels of macro nesting.

Note: If a symbolic parameter is only a part of the value specified in an inner macro instruction operand, only the character string value given to the parameter by an outer call is passed through the nesting level. Inner sublist entries and attributes of symbols are not available for reference in the inner macro.

SYSTEM VARIABLE SYMBOLS IN NESTED MACROS

The global read-only system variable symbols (&SYSPARM, &SYSDATE, and &SYSTIME) are not affected by the nesting of macros. The remaining system variable symbols are given local read-only values that depend on the position of a macro instruction in code and the operand value specified in the macro instruction.

If &SYSLIST is specified in a macro definition called by an inner macro instruction, &SYSLIST refers to the positional operands of the inner macro instruction.

The assembler increments &SYSNDX by one each time it encounters a macro call. It retains the incremented value throughout the expansion of the macro definition called, that is, within the local scope of the nesting level.

The assembler gives &SYSECT the character string value of the name of the control section in force at the point at which a macro call is made. For a macro definition called by an inner macro call, the assembler will assign to &SYSECT the name of the control section generated in the macro definition that contains the inner macro call. The control section must be generated before the inner macro call is processed.

If no control section is generated within a macro definition, the value assigned to &SYSECT does not change. It is the same for the next level of macro definition called by an inner macro instruction.

The assembler gives &SYSLOC the character string value of the name of the location counter in use at the point at which a macro call is made. For a macro definition called by an inner macro call, the assembler will assign to &SYSLOC the name of the location counter in effect in the macro definition that contains the inner macro call.

&SYSECT and &SYSLOC have local scope; their read-only values remain constant throughout the expansion of the called macro definition.

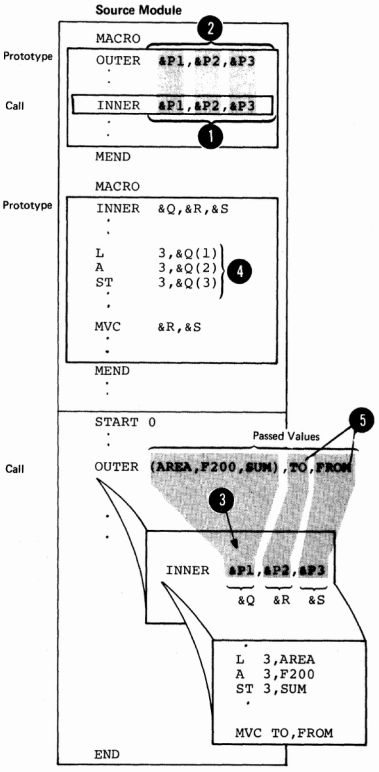


Figure 49. Passing Values through Nesting Levels

CHAPTER 9. HOW TO WRITE CONDITIONAL ASSEMBLY INSTRUCTIONS

This chapter describes the conditional assembly language. With the conditional assembly language, you can perform general arithmetic and logical computations, as well as many of the other functions you can perform with any other programming language. In addition, by writing conditional assembly instructions in combination with other assembler language statements, you can:

- Select sequences of these source statements, called model statements, from which machine and assembler instructions are generated
- Vary the contents of these model statements during generation

The assembler processes the instructions and expressions of the conditional assembly language at preassembly time. Then, at assembly time, it processes the generated instructions. Conditional assembly instructions, however, are not processed after preassembly time.

The conditional assembly language is more versatile when used to interact with symbolic parameters and the system variable symbols inside a macro definition. However, you can also use the conditional assembly language in open code; that is, code in an assembler language source program.

ELEMENTS AND FUNCTIONS

The elements of the conditional assembly language are:

- SET symbols that represent data
- Attributes that represent different characteristics of data
- Sequence symbols that act as labels for branching to statements at preassembly time

The functions of the conditional assembly language are:

- Declaring SET symbols as variables for use by the conditional assembly language in its computations
- Assigning values to the declared SET symbols
- Evaluating conditional assembly expressions used as values for substitution, as subscripts for variable symbols, or as condition tests for branch instructions
- Selecting characters from strings for substitution in, and concatenation to, other strings; or for inspection in condition tests
- Branching and exiting from conditional assembly loops

SET SYMBOLS

SET symbols are variable symbols that provide you with arithmetic, binary, or character data, and whose values you can vary at preassembly time.

You can use SET symbols as:

- Terms in conditional assembly expressions
- Counters, switches, and character strings

- Subscripts for variable symbols
- Values for substitution

Thus, SET symbols allow you to control your conditional assembly logic, and to generate many different statements from the same model statement.

Subscripted SET Symbols

You can use a SET symbol to represent an array of many values. You can then refer to any one of the values of this array by subscripting the SET symbol.

Scope of SET Symbols

The scope of a SET symbol is that part of a program for which the SET symbol has been declared. Local SET symbols need not be declared by explicit declarations. The assembler considers any undeclared variable symbol found in the name field of a SETx instruction as a local SET symbol.

If you declare a SET symbol to have a local scope, you can use it only in the statements that are part of:

- The same macro definition, or
- Open code

If you declare a SET symbol to have a global scope, you can use it in the statements that are part of:

- The same macro definition,
- A different macro definition, and
- Open code

You must, however, declare the SET symbol as global for each part of the program (a macro definition or open code) in which you use it.

You can change the value assigned to a SET symbol without affecting the scope of this symbol.

SCOPE OF OTHER VARIABLE SYMBOLS: A symbolic parameter has a local scope. You can use it only in the statements that are part of the macro definition for which the parameter is declared. You declare a symbolic parameter in the prototype statement of a macro definition.

The system variable symbols &SYSLIST, &SYSECT, &SYSLOC, and &SYSNDX have a local scope; you can use them only inside macro definitions. However, the system variable symbols &SYSPARM, &SYSDATE, and &SYSTIME have a global scope; you can use them in both open code and inside any macro definition.

SET Symbol Specifications

SET symbols can be used in model statements, from which assembler language statements are generated, and in conditional assembly instructions.

The three types of SET symbols are: SETA, SETB, and SETC. A SET symbol must be a valid variable symbol. The format of a SET symbol is:

- The first column must contain an ampersand (&).
- The second column must contain an alphabetic character.
- The remaining columns must contain 0 to 61 alphameric characters.

Examples of SET symbols are:

```
&ARITHMETICVALUE439
&BOOLEAN
&C
```

Local SET symbols need not be declared by explicit declarations. The assembler considers any undeclared variable symbol found in the name field of a SETx instruction as a local SET symbol. The instruction that declares a SET symbol determines its scope and type.

The features of SET symbols and other types of variable symbols are compared in Figure 50.

	Types of Variable Symbol		
Feature	SETA, SETB, or SETC Symbols	Symbolic Parameters	System Variable Symbols
Can be used: In open code	YES	NO	only: &SYSPARM [redacted]
In macro definitions	YES	YES	All
Scope: Local or	YES	YES	&SYSLIST &SYSECT &SYSLOC &SYSNDX
Global	YES	NO	&SYSPARM [redacted]
Values can be changed within scope of symbol	(1) YES	(2) NO: read only value	(2) NO: read only value

Figure 50. Features of SET Symbols and Other Types of Variable Symbols

The value assigned to a SET symbol can be changed (see (1) in Figure 50) by using the SETA, SETB, or SETC instruction within the declared scope of the SET symbol. However, a symbolic parameter and the system variable symbols are assigned values that remain fixed (see (2) in Figure 50) throughout their scope. Wherever a SET symbol appears in a statement, the assembler replaces the symbol with the last value assigned to the symbol.

Note: SET symbols can be used in the name and operand fields of macro instructions. However, the value thus passed through a symbolic parameter into a macro definition is considered as a character string and is generated as such.

Subscripted SET Symbols Specifications

A subscripted SET symbol must be specified as shown below:

```
Format:          &SETSYM(subscript)

where:

• &SETSYM is a variable symbol.
• 'subscript' is an arithmetic expression, whose value must
  not be 0 or negative.

For example:  LCLA  &ARRAY(20)
```

The subscript can be any arithmetic expression allowed in the operand field of a SETA instruction (see "Arithmetic (SETA) Expressions" below).

A subscripted SET symbol can be used anywhere an unscripted SET symbol is allowed. However, subscripted SET symbols must be declared as subscripted by a previous local or global declaration instruction.

The subscript refers to one of the many positions in an array of values identified by the SET symbol.

The dimension (the maximum value of the subscript) of a subscripted SET symbol is not determined by the explicit or implicit declaration of the symbol. The dimension specified can be exceeded in subsequent SETx instructions.

Note: The subscript can be a subscripted SET symbol. Five levels of subscript nesting are allowed.

Created SET Symbols

Assembler H can create SET symbols during conditional assembly processing from other variable symbols and character strings. A SET symbol thus created has the form &(e), where "e" represents one or more of the following:

- Variable symbols, optionally subscripted
- Strings of alphameric characters
- Other created SET symbols

After substitution and concatenation, "e" must consist of a string of up to 62 alphameric characters, the first of which is alphabetic. The assembler will consider the preceding ampersand and this string as the name of a SET variable.

You can use created SET symbols wherever ordinary SET symbols are permitted, including declarations. You can also nest them in other created SET symbols.

Consider the following example:

Name	Operation	Operand
&ABC(1)	SETC	'MKT','27','$5'

Let &(e) equal &(&ABC(&I)QUA&I).

&I	&ABC(&I)	Created SET Symbol	Comment
1	MKT	&MKTQUA1	Valid
2	27	&27QUA2	Invalid: first character after '&' not alphabetic
3	$5	&$5QUA3	Valid
4		&QUA4	Valid

The created SET symbol can be thought of as a form of indirect addressing. With nested created SET symbols, you can get this kind of indirect addressing to any level.

In another sense, created SET symbols offer an associative storage facility. For example, a symbol table of numeric attributes can be referred to by an expression of the form &(&SYM)(&I) to yield the "Ith" attribute of the symbol name in &SYM.

Created SET symbols also enable you to get some of the effect of multiple-dimensioned arrays by creating a separate name for each element of the array. For example, a 3-dimensional array of the form &X(&I,&J,&K) could be addressed as &(X&I.$&J.$&K). Thus, &X(2,3,4) would be represented by &X23$4. The $s guarantee that &X(2,33,55) and &X(23,35,5) are unique:

```
&X(2,33,55) becomes &X2$33$55
&X(23,35,5) becomes &X23$35$5
```

DATA ATTRIBUTES

The data, such as instructions, constants, and areas, which you define in a source module, can be described in terms of:

- Type, which distinguishes one form of data from another; for example, fixed-point constants from floating-point constants, or machine instructions from macro instructions
- Length, which gives the number of bytes occupied by the object code of the data
- Scaling, which indicates the number of positions occupied by the fractional portion of fixed-point and decimal constants in their object code form
- Integer, which indicates the number of positions occupied by the integer portion of fixed-point and decimal constants in their object code form
- Count, which gives the number of characters that would be required to represent the data, such as a macro instruction operand, as a character string
- Number, which gives the number of sublist entries in a macro instruction operand
- Defined, which determines whether a symbol has been defined prior to the point where the attribute reference is coded

These characteristics are called the attributes of the data. The assembler assigns attribute values to the ordinary symbols and variable symbols that represent the data.

Specifying attributes in conditional assembly instructions allows you to control conditional assembly logic, which, in turn, can control the sequence and contents of the statements generated from model statements. The specific purpose for which you use an attribute depends on the kind of attribute being considered. The attributes and their main uses are shown below:

Attribute	Purpose	Main Uses
Type	Gives a letter that identifies type of data represented	- In tests to distinguish between different data types - For value substitution - In macros to discover missing operands
Length	Gives number of bytes that data occupies in storage	- For substitution into length fields - For computation of storage requirements
Scaling	Refers to the position of the decimal point in decimal, fixed-point, and floating-point constants	- For testing and regulating the position of decimal points - For substitution into a scale modifier
Integer	Is a function of the length and scaling attributes of decimal, fixed-point, and floating-point constants	- To keep track of significant digits (integers)
Count	Gives the number of characters required to represent data	- For scanning and decomposing of character strings - As indexes in substring notation
Number[1]	Gives the number of sublist entries in a macro instruction operand sublist	- For scanning sublists - As counter to test for end of sublist
Defined	Indicates whether the symbol referenced has been defined prior to the attribute reference	- To avoid assembling a statement again if the symbol referenced has been previously defined

Note

1 The number attribute of &SYSLIST(m) and &SYSLIST(m,n) is described in "&SYSLIST—Macro Instruction Operand" on page 173.

The format for an attribute reference is:

```
          '
Attribute   Ordinary or
Notation    Variable Symbol
```

For example:

```
T'SYMBOL
L'&VAR
K'&PARAM
```

The attribute notation indicates the attribute whose value is desired. The ordinary or variable symbol represents the data that possesses the attribute. The assembler substitutes the value of the attribute for the attribute reference.

An attribute reference to the type, scaling, integer, count, and number attributes can be used only in a conditional assembly instruction. The length attribute reference can be used both in a conditional assembly instruction and in a machine or assembler instruction.

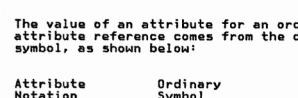
Combination with Symbols

Figure 51 shows the seven kinds of attributes, identifying the types of symbols they can be combined with.

	ATTRIBUTES SPECIFIED						
SYMBOLS SPECIFIED	Type T'	Length L'	Scaling S'	Integer I'	Count K'	Number N'	Defined D'
IN THE OPEN CODE Ordinary Symbols	YES	YES	YES	YES	NO	NO	YES
SET Symbols	YES	SETC only	SETC only	SETC only	YES	YES subscripted	SETC only
System Variable Symbols: &SYSPARM &SYSDATE &SYSTIME	YES	NO	NO	NO	YES	NO	NO
IN MACRO DEFINITIONS Ordinary Symbols	YES	YES	YES	YES	NO	NO	YES
SET Symbols	YES	SETC only	SETC only	SETC only	YES	YES subscripted	SETC only
Symbolic Parameters	YES	YES	YES	YES	YES	YES	YES
System Variable Symbols: &SYSLIST	YES	YES	YES	YES	YES	YES	YES
&SYSECT, &SYSLOC, &SYSNDX, &SYSPARM, &SYSDATE, &SYSTIME	YES	NO	NO	NO	YES	NO	NO

Figure 51. Attributes and Related Symbols

The value of an attribute for an ordinary symbol specified in an attribute reference comes from the data represented by the symbol, as shown below:



The symbol must appear in the name field of an assembler or machine instruction, or in the operand field of an EXTRN or WXTRN instruction. The instruction in which the symbol is specified:

- Must appear in open code
- Must not contain any variable symbols

Note: You can refer to instructions generated by conditional assembly substitution or macro expansion with attributes. However, no such reference can be made until the instruction is generated.

The value of an attribute for a variable symbol specified in an attribute reference comes from the value substituted for the variable symbol as follows:

1. For SET symbols and the system variable symbols: &SYSECT, &SYSLOC, &SYSNDX, &SYSPARM, &SYSDATE, and &SYSTIME, the attribute values come from the current data value of these symbols.

2. For symbolic parameters and the system variable symbol, &SYSLIST, the values of the count and number attributes come from the operands of macro instructions.

   The values of the type, length, scaling, and integer attributes, however, come from the values represented by the macro instruction operands, as follows:

   a. If the operand is a sublist, the entire sublist and each entry of the sublist can possess attributes; all the individual entries and the whole sublist have the same attributes as those of the first suboperand in the sublist (except for "count," which can be different, and "number," which is relevant only for the whole sublist).

   b. If the first character or characters of the operand (or sublist entry) constitute an ordinary symbol, and this symbol is followed by either an arithmetic operator (+, -, *, or /), a left parenthesis, a comma, or a blank, then the value of the attributes for the operand are the same as for the ordinary symbol.

   c. If the operand (or sublist entry) is a character string other than a sublist or the character string described in b above, the type attribute is undefined (U) and the length, scaling, and integer attributes are invalid.

Because attribute references are allowed only in conditional assembly instructions, their values are available only at preassembly time, except for the length attribute which can be referred to outside conditional assembly instructions, and is, therefore, also available at assembly time.

Note: The system variable symbol, &SYSLIST, can be used in an attribute reference to refer to a macro instruction operand, and, in turn, to an ordinary symbol. Thus, any of the attribute values for macro instruction operands and ordinary symbols

listed below can also be substituted for an attribute reference containing &SYSLIST.

Type Attribute (T')

The type attribute has a value of a single alphabetic character that indicates the type of data represented by:

- An ordinary symbol
- A macro instruction operand
- A SET symbol.

The type attribute reference can be used only in the operand field of the SETC instruction or as one of the values used for comparison in the operand field of a SETB or AIF instruction.

Notes:

1. Ordinary symbols used in the name field of an EQU instruction have the type attribute value "U." However, the third operand of an EQU instruction can be used explicitly to assign a type attribute value to the symbol in the name field.

2. The type attribute of a sublist is set to the same value as the type attribute of the first element of the sublist.

The following letters are used for the type attribute of data represented by ordinary symbols and outer macro instruction operands that are symbols that name DC or DS statements.

A A-type address constant, implied length, aligned (also CXD instruction label)
B Binary constant
C Character constant
D Long floating-point constant, implicit length, aligned
E Short floating-point constant, implicit length, aligned
F Fullword fixed-point constant, implicit length, aligned
G Fixed-point constant, explicit length
H Halfword fixed-point constant, implicit length, aligned
K Floating-point constant, explicit length
L Extended floating-point constant, implicit length, aligned
P Packed decimal constant
Q Q-type address constant, implicit length, aligned
R A-, S-, Q-, V-, or Y-type address constant, explicit length
S S-type address constant, implicit length, aligned
V V-type address constant, implicit length, aligned
X Hexadecimal constant
Y Y-type address constant, implicit length, aligned
Z Zoned decimal constant

The following letters are used for the type attribute of data represented by ordinary symbols (and outer macro instruction operands that are symbols) that name statements other than DC or DS statements, or that appear in the operand field of an EXTRN or WXTRN statement.

I Machine instruction
J Identified as a control section name
M Macro instruction
T Identified as an external symbol by EXTRN instruction
W CCW, CCW0, or CCW1 instruction
$ Identified as an external symbol by WXTRN instruction

The following letters are used for the type attribute of data represented by inner and outer macro instruction operands only.

N Self-defining term or the value of a SETA or SETB variable
O Omitted operand (has a value of a null character string)

The following letter is used for symbols or macro instruction operands that cannot be assigned any of the above letters.

U Undefined

The type attribute value U is assigned to the following:

- Ordinary symbols used as labels:
  - For the LTORG instruction
  - For the EQU instruction without a third operand
  - For DC and DS statements that contain variable symbols; for example, U1 DC &X'1'
  - That are defined more than once, even though only one label will be generated due to conditional assembly statements
- SETC variable symbol
- System variable symbols: &SYSPARM, &SYSDATE, and &SYSTIME
- Macro instruction operands that specify literals
- Inner macro instruction operands that are ordinary symbols

Note: Because Assembler H allows attribute references to statements generated through substitution, certain cases in which a type attribute of U (undefined) or M (macro) is given under the OS/VS Assembler, may give a valid type attribute under Assembler H. If the value of the SETC symbol is equal to the name of an instruction that can be referred to by the type attribute, Assembler H allows you to use the type attribute with a SETC symbol.

Length Attribute (L')

The length attribute has a numeric value equal to the number of bytes occupied by the data that is represented by the symbol specified in the attribute reference.

If the length attribute value is desired for preassembly processing, the symbol specified in the attribute reference must ultimately represent the name entry of a statement in open code. In such a statement, the length modifier (for DC and DS instructions) or the length field (for a machine instruction), if specified, must be a self-defining term. The length modifier or length field must not be coded as a multiterm expression, because the assembler does not evaluate this expression until assembly time.

Assembler H allows you to use the length attribute with a SETC symbol, if the value of the SETC symbol is equal to the name of an instruction that can be referenced by the length attribute.

The length attribute can also be specified outside conditional assembly instructions. Then, the length attribute value is not available for conditional assembly processing, but is used as a value at assembly time.

At preassembly time, an ordinary symbol used in the name field of an EQU instruction has a length attribute value of 1. At assembly time, the symbol has the same length attribute value as the first symbol of the expression in the first operand of the EQU instruction. However, the second operand of an EQU instruction can be used to assign a length attribute value to the symbol in the name field.

Notes:

1. The length attribute reference, when used in conditional assembly processing, can be specified only in arithmetic expressions.

2. A length attribute reference to a symbol with the type attribute value of M, N, O, T, U, or $ will be flagged. The length attribute for the symbol will be given the default value of 1.

Scaling Attribute (S')

The scaling attribute can be used only when referring to fixed-point, floating-point, or decimal constants. It has a numeric value that is assigned as shown below:

Constant Types Allowed	Type Attributes Allowed	Value of Scaling Attribute Assigned
Fixed-Point	H, F, and G	Equal to the value of the scale modifier (-187 through +346)
Floating Point	D, E, L, and K	Equal to the value of the scale modifier (0 through 14 - D, E) (0 through 28 - L)
Decimal	P and Z	Equal to the number of decimal digits specified to the right of the decimal point (0 through 31 - P) (0 through 16 - Z)

Notes:

1. The scaling attribute reference can be used only in arithmetic expressions.

2. When no scaling attribute value can be determined, the reference is flagged and the scaling attribute is given the value of 1.

3. If the value of the SETC symbol is equal to the name of an instruction that can be referenced by the scaling attribute, Assembler H allows you to use the scaling attribute with a SETC symbol.

Integer Attribute (I')

The integer attribute has a numeric value that is a function of (depends on) the length and scaling attribute values of the data being referred to by the attribute reference. The formulas relating the integer attribute to the length and scaling attributes are given in Figure 52 on page 206.

Constant Type Allowed (attribute value)	Formula Relating the Integer to the Length and Scaling Attributes (1)	Examples	Values Of the Integer Attribute
Fixed-point (H,F, and G)	I'=8*L'-S'-1	HALFCON DC HS6'-25.93' 8*2-6-1 ONECON DC FS8'100.3E-2' 8*4-8-1	9 23
Floating-point (D,E,L, and K)	when L' ≤ 8 I'=2*(L'-1)-S'	SHORT DC ES2'46.415' 2*(4-1)-2 LONG DC DS5'-3.729' 2*(8-1)-5	4 9
Only for L-Type	when L' > 8 I'=2*(L'-1)-S'-2	EXTEND DC LS10'5.312' 2*(16-1)-10 -2	18
Decimal equal to the number of decimal digits to the left of the assumed decimal point after the number is assembled			
Packed (P)	I'=2*L'-S'-1	PACK DC P'+3.513' 2*3-3-1 03 513C	2
Zoned (Z)	I'=L'-S'	ZONE DC Z'3.513' 4-3	1

Figure 52. Relationship of Integer to Length and Scaling Attributes

Notes:

1. The integer attribute reference can be used only in arithmetic expressions.
2. If the value of the SETC symbol is equal to the name of an instruction that can be referenced by the integer attribute, Assembler H allows you to use the integer attribute with a SETC symbol.

Count Attribute (K')

The count attribute applies only to macro instruction operands, to SET symbols, and to the system variable symbols. It has a numeric value equal to the number of characters:

- That constitute the macro instruction operand, or

- That would be required to represent as a character string the current value of the SET symbol or the system variable symbol.

Notes:

1. The count attribute reference can be used only in arithmetic expressions.

2. The count attribute of an omitted macro instruction operand has a default value of 0.

Number Attribute (N')

The number attribute applies only to the operands of macro instructions. It has a numeric value equal to the number of sublist entries in the operand.

When applied to a subscripted SET symbol, the number attribute is equal to the highest element to which a value has been assigned in a SETx instruction. For example, if the only references to &A have been

```
        LCLA  &A(100)
&A(5)   SETA  20,,,70              (see description of
        AIF   (&A(20) GT 50).M     extended SET statements)
```

then N'&A is equal to 8, because &A(8) is assigned the value 70.

Notes:

1. The number attribute reference can be used only in arithmetic expressions.

2. N'&SYSLIST refers to the number of positional operands in a macro instruction, and N'&SYSLIST(m) refers to the number of sublist entries in the m-th operand.

Defined Attribute (D')

The defined attribute indicates whether or not the symbol referenced has been defined prior to the attribute reference. A symbol is considered as defined if it has been encountered in the operand field of an EXTRN or WXTRN statement, or in the name field of any other statement. The value of the defined attribute is 1, if the symbol has been defined, or 0, if the symbol has not been defined.

The defined attribute can reference all symbols that can be referenced by the scaling (S') attribute.

The following is an example of how you can use the defined attribute:

```
          AIF   (D'A).AROUND
A         LA    1,4
.AROUND   ANOP
```

In this example, the statement at A would be assembled, since the branch around it would not be taken. However, if by a branch the same statement were processed again, the statement at A would not be assembled:

```
.UP       AIF   (D'A).AROUND
A         LA    1,4
.AROUND   ANOP
          .
          AGO   .UP
```

You can save assembly time using the defined attribute. Each time the assembler finds a reference (attribute or branch) to an undefined symbol, it initiates a forward scan until it finds

that symbol or reaches the END statement. You can use the defined attribute in your program to prevent the assembler from making this time-consuming forward scan.

SEQUENCE SYMBOLS

You can use a sequence symbol in the name field of a statement to branch to that statement at preassembly time, thus altering the sequence in which the assembler processes your conditional assembly and macro instructions. You can thus select the model statements from which the assembler generates assembler language statements for processing at assembly time.

Sequence symbols must be specified as follows:

- The first column must contain a period (.).
- The second column must contain an alphabetic character.
- The remaining columns must contain 0 to 61 alphameric characters.

For example: .BRANCHINGLABEL1
.A

Sequence symbols can be specified in the name field of assembler language statements and model statements; however, the following lists assembler instructions in which sequence symbols must not be used as name entries:

```
COPY
EQU
GBLA
GBLB
GBLC
ICTL
ISEQ
LCLA
LCLB
LCLC
MACRO
OPSYN
```

In addition, sequence symbols cannot be used as name entries in macro prototype instructions, or in any instruction that already contains an ordinary or a variable symbol.

Sequence symbols can be specified in the operand field of an AIF or AGO instruction to branch to a statement with the same sequence symbol as a label.

A sequence symbol has a local scope. Thus, if a sequence symbol is used in an AIF or an AGO instruction, the sequence symbol must be defined as a label in the same part of the program in which the AIF or AGO instruction appears; that is, in the same macro definition or in open code.

If a sequence symbol appears in the name field of a macro instruction, and the corresponding prototype statement contains a symbolic parameter in the name field, the sequence symbol does not replace the symbolic parameter wherever it is used in the macro definition.

The following example illustrates this rule.

	Name	Operation	Operand
		MACRO	
1	&NAME	MOVE	&TO,&FROM
2	&NAME	ST	2,SAVEAREA
		L	2,&FROM
		ST	2,&TO
		L	2,SAVEAREA
		MEND	
3	.SYM	MOVE	FIELDA,FIELDB
4		ST	2,SAVEAREA
		L	2,FIELDB
		ST	2,FIELDA
		L	2,SAVEAREA

The symbolic parameter &NAME is used in the name field of the prototype statement (statement 1) and the first model statement (statement 2). In the macro instruction (statement 3), a sequence symbol (.SYM) corresponds to the symbolic parameter &NAME. &NAME is not replaced by .SYM and, therefore, the generated statement (statement 4) does not contain an entry in the name field.

ATTRIBUTE DEFINITION AND LOOKAHEAD

Symbol attributes are established in either definition mode or lookahead mode. Lookahead mode is entered when Assembler H encounters an attribute reference to a symbol that is not yet defined.

DEFINITION MODE: Definition occurs whenever a previously undefined symbol is encountered in the name field of a statement, or in the operand field of an EXTRN or WXTRN statement during open code processing. Symbols within a macro definition are defined when the macro is generated.

Lookahead Mode: Lookahead is a sequential, statement-by-statement, forward scan over the source text. It is initiated when reference is made to an attribute (other than D') of a symbol not yet encountered, either by macro or open-code attribute reference, or by a forward AGO or AIF branch in open code.

If reference is made in a macro, forward scan begins with the first source statement following the outermost macro instruction. Programmer macros are bypassed. The text is not assembled. Lookahead attributes are tentatively established for all intervening undefined symbols. Tentative attributes are replaced and fixed when the symbol is subsequently encountered in definition mode. No macro expansion or open-code substitution is performed; no conditional or unconditional (AIF or AGO) branches are taken. COPY instructions are executed during lookahead, and the copied statements are scanned.

Lookahead ends when the desired symbol or sequence symbol is found, or when the END card or end of file is reached. All statements passed over by lookahead are saved on an internal file, and processed when the lookahead ends.

For purposes of attribute definition, a symbol is considered undefined if it depends in any way upon a symbol not yet defined. For example, if the symbol is defined by a forward EQU that is not yet resolved, or if a DC, DS, or DXD modifier expression contains symbols not yet defined, that symbol is assigned a type attribute of U.

Note: Because no variable symbol substitution is performed by a lookahead, you should be careful when using a macro or open code substitution to generate END statements that separate source modules assembled in one job step (option BATCH). If a symbol is undefined within a module, lookahead will read in records past the point where the END statement is to be generated. All statements between the generated statement and the point at which lookahead stops (either because it finds a matching symbol, or because it finds an END statement) are ignored by the assembler. The next module will start at the point where lookahead stops.

LOOKAHEAD RESTRICTIONS: Assembler statements are analyzed only to the extent necessary to establish attributes of symbols in their name fields.

Variable symbols are not replaced. Modifier expressions are evaluated only if all symbols involved were defined prior to lookahead. Possible multiple or inconsistent definition of the same symbol is not diagnosed during lookahead because conditional assembly may eliminate one (or both) of the definitions.

Lookahead does not check undefined operation codes against library (system) macro names. If the name field contains an ordinary symbol and the operation code cannot be matched with one in the current operation code table, then the ordinary symbol is assigned the type attribute of M. If the operation code contains special characters or is a variable symbol, a type attribute of U is assumed. This may be wrong if the undefined operation code is later defined by OPSYN. OPSYN statements are not processed; thus, labels are treated in accordance with the operation code definitions in effect at the time of entry to lookahead.

DECLARING SET SYMBOLS

You must declare a global SET symbol before you can use it. The assembler assigns an initial value to a global SET symbol at its point of declaration.

Local SET symbols need not be declared explicitly with LCLA, LCLB, or LCLC statements. The assembler considers any undeclared variable symbol found in the name field of a SETA, SETB, or SETC statement to be a local SET symbol. It is given the initial value specified in the operand field. If the symbol in the name field is subscripted, it is declared as a subscripted SET symbol.

LCLA, LCLB, LCLC—DEFINE LOCAL SET SYMBOLS

You use the LCLA, LCLB, and LCLC instructions to declare the local SETA, SETB, and SETC symbols you need. The SETA, SETB, and SETC symbols are assigned the initial values of 0, 0, and null character string, respectively.

The format of these instructions is:

Name	Operation	Operand
Blank	LCLA, LCLB, or LCLC	One or more variable symbols separated by commas

These instructions can be used anywhere in the body of a macro definition or in the open code portion of a source module.

A local SET symbol should not begin with &SYS because these characters are reserved for system variable symbols.

Any variable symbols declared in the operand field have a local scope. They can be used as SET symbols anywhere after the pertinent LCLA, LCLB, or LCLC instructions, but only within the declared local scope. Multiple LCLx statements can declare the same variable symbol if only one declaration for a given symbol is encountered during the expansion of a macro.

The following rules apply to a local SET variable symbol:

1. Within a macro definition, it must not be the same as any symbolic parameter declared in the prototype statement.

2. It must not be the same as any global variable symbol declared within the same local scope.

3. The same variable symbol must not be declared or used as two different types of SET symbols; for example, as a SETA and a SETB symbol, within the same local scope.

SUBSCRIPTED LOCAL SET SYMBOLS: A local subscripted SET symbol is declared by the LCLA, LCLB, or LCLC instruction. This declaration must be specified as follows:

Format:

```
   LCLA ┐
   LCLB ├ &SETSYM(dimension)
or LCLC ┘
```

where

```
  &SETSYM    is a variable symbol.
  dimension must be an unsigned, decimal, self-defining term,
            but not 0.
```

For example:

```
  LCLB  &B(10)
```

There is no limit to SET symbol dimensioning. The limit specified in the explicit (LCLx) or implicit (SETx) declaration can also be exceeded by subsequent SETx statements. The dimension indicates the number of SET variables associated with the subscripted SET symbol. The assembler assigns an initial value to every variable in the array thus declared.

Note: A subscripted local SET symbol can be used only if the declaration has a subscript, which represents a dimension; a nonsubscripted local SET symbol can be used only if the declaration had no subscript.

ALTERNATIVE FORMAT FOR LCLX STATEMENTS: Assembler H permits an alternative statement format for LCLx instructions; for example:

```
Statement                                    Continuation
Field                                        Indicator

LCLA        &LOCALSYMBOLFORDCGEN,            X
            &COUNTERFORINNERLOOP,            X
            &COUNTERFOROUTERLOOP,            X
            &COUNTERFORTRAILINGLOOP
```

GBLA, GBLB, AND GBLC INSTRUCTIONS

You use the GBLA, GBLB, and GBLC instructions to declare the global SETA, SETB, and SETC symbols you need. The SETA, SETB, and SETC symbols are assigned the initial values of 0, 0, and null character string, respectively.

The format of the GBLA, GBLB, and GBLC instruction statements is as follows:

Name	Operation	Operand
Blank	GBLA, GBLB, or GBLC	One or more variable symbols separated by commas

These instructions can be used anywhere in the body of a macro definition or in the open code portion of a source module.

Any variable symbols declared in the operand field have a global scope. They can be used as SET symbols anywhere after the pertinent GBLA, GBLB, or GBLC instructions. However, they can be used only within those parts of a program in which they have been declared as global SET symbols; that is, in any macro definition and in open code.

The assembler assigns an initial value to the SET symbol only when it processes the first GBLA, GBLB, or GBLC instruction in which the symbol appears. Subsequent GBLA, GBLB, or GBLC instructions do not reassign an initial value to the SET symbol.

Multiple GLBx statements can declare the same variable symbol if only one declaration for a given symbol is encountered during the expansion of a macro.

The following rules apply to the global SET variable symbol:

1. Within a macro definition, it must not be the same as any symbolic parameter declared in the prototype statement.
2. It must not be the same as any local variable symbol declared within the same local scope.
3. The same variable symbol must not be declared or used as two different types of global SET symbol; for example, as a SETA or SETB symbol.

Note: A global SET symbol should not begin with the four characters &SYS, which are reserved for system variable symbols.

SUBSCRIPTED GLOBAL SET SYMBOLS: A global subscripted SET symbol is declared by the GBLA, GBLB, or GBLC instruction.

This declaration must be specified as follows:

Format:

```
   GBLA   ┐
   GBLB   > &SETSYM(dimension)
or GBLC   ┘
```

where

```
  &SETSYM   is a variable symbol.
  dimension must be an unsigned, decimal, self-defining term,
            but not 0.
```

For example:

```
  GBLA  &GA
```

There is no limit on the maximum subscript allowed. Also, the limit specified in the global declaration (GBLx) can be exceeded. The dimension indicates the number of SET variables associated with the subscripted SET symbol. The assembler assigns an initial value to every variable in the array thus declared.

Notes:

1. Global arrays are assigned initial values only by the first global declaration processed, in which a global subscripted SET symbol appears.

2. A subscripted global SET symbol can be used only if the declaration has a subscript, which represents a dimension; a nonsubscripted global SET symbol can be used only if the declaration had no subscript.

3. Wherever a particular global SET symbol is declared with a dimension as a subscript, the dimension must be the same in each declaration.

ALTERNATIVE FORMAT FOR GBLX STATEMENTS: Assembler H permits the alternate statement format for GBLx instructions, as shown in the following example:

```
Statement                                          Continuation
Field                                              Indicator

GBLA        &GLOBALSYMBOLFORDCGEN,                 X
            &LOOPCONTRLA,                          X
            &VALUEPASSEDTOMACDUFF,                 X
            &VALUERETURNEDFROMMACDUFF
```

ASSIGNING VALUES TO SET SYMBOLS

SETA—SET ARITHMETIC

The SETA instruction allows you to assign an arithmetic value to a SETA symbol. You can specify a single value or an arithmetic expression from which the assembler will compute the value to assign.

You can change the values assigned to an arithmetic or SETA symbol. This allows you to use SETA symbols as counters, indexes, or for other repeated computations that require varying values.

The format of this instruction is:

Name	Operation	Operand
A variable symbol	SETA	An arithmetic expression

A global variable symbol in the name field must have been previously declared as a SETA symbol in a GBLA instruction. Local SETA symbols need not be declared in a LCLA instruction. The assembler considers any undeclared variable symbol found in the name field of a SETA instruction as a local SET symbol.

The variable symbol is assigned a type attribute value of N.

The expression in the operand field is evaluated as a signed 32-bit arithmetic value that is assigned to the SETA symbol in the name field. The minimum and maximum allowable values of the expression are -2^{31} and $+2^{31}-1$, respectively.

Subscripted SETA Symbols

The SETA symbol in the name field can be subscripted, but only if the same SETA symbol has been previously declared in a GBLA or LCLA instruction with an allowable dimension.

The assembler assigns the value of the expression in the operand field to the position in the declared array given by the value of the subscript. The subscript expression must not be 0, or have a negative value, or exceed the dimension actually specified in the declaration.

Arithmetic (SETA) Expressions

Arithmetic expressions can be used as shown in Figure 53.

Can be Used In	Used As	Example
SETA instruction	operand	`&A1 SETA &A1+2`
AIF instruction or SETB instruction	comparand in arithmetic relation	`AIF (&A*10 GT 30).A`
Subscripted SET symbols	subscript	`&SETSYM(&A+10-&C)`
Substring notation (See L6)	subscript	`'&STRING'(&A*2,&A-1)`

Sublist notation	subscript	`sublist (A,B,C,D)`
		when &A=1
		`&PARAM(&A+1)=B`

&SYSLIST	subscript	`&SYSLIST(&M+1,&N-2)` `&SYSLIST(N'&SYSLIST)`
SETC instruction	character string in operand	`&C SETC '5-10*&A'` (1) if &A=10 → (2) then &C=5-10*10

Figure 53. Using Arithmetic (SETA) Expressions

Note: When an arithmetic expression is used in the operand field of a SETC instruction (see (1) in Figure 53), the assembler assigns the character value representing the arithmetic expression to the SETC symbol, after substituting values (see (2) in Figure 53) into any variable symbols. It does not evaluate the arithmetic expression.

Figure 54 on page 215 defines an arithmetic expression.

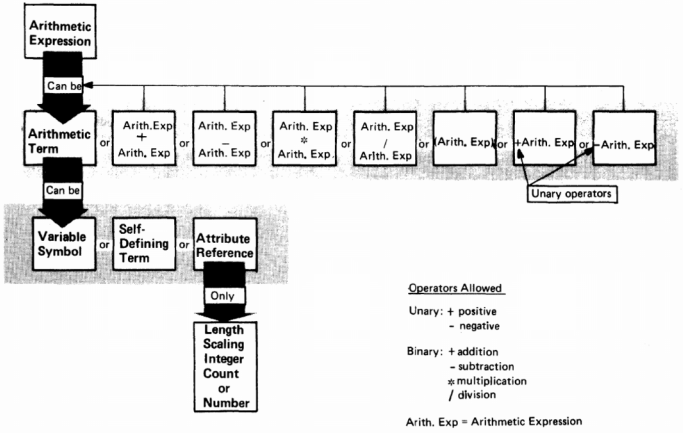


Figure 54. Defining Arithmetic (SETA) Expressions

The variable symbols that are allowed as terms in an arithmetic expression are given in Figure 55 on page 216.

RULES FOR CODING ARITHMETIC EXPRESSIONS: The following is a summary of coding rules for arithmetic expressions:

1. Both unary (operating on one value) and binary (operating on two values) operators are allowed in arithmetic expressions.
2. An arithmetic expression can have one or more unary operators preceding any term in the expression or at the beginning of the expression. The unary operators are + (positive) and - (negative).
3. The binary operators that can be used to combine the terms of an expression are + (addition), - (subtraction), * (multiplication), and / (division).
4. An arithmetic expression must not begin with a binary operator, and it must not contain two binary operators in succession.
5. An arithmetic expression must not contain two terms in succession.
6. An arithmetic expression must not contain blanks between an operator and a term, nor between two successive operators.

7. An arithmetic expression can contain up to 24 unary and binary operators, and up to 255 levels of parentheses.

Note: The parentheses required for sublist notation, substring notation, and subscript notation count toward this limit.

Variable Symbol	Restrictions	Example	Value
SETA	none	—	—
SETB	none	—	—
SETC &SYSPARM	value must be an unsigned decimal self-defining term in the range 0 through 2,147,483,647	&C &SYSPARM	123 2000
Symbolic Parameters	value must be a self-defining term	&PARAM &SUBLIST(3)	X'A1' C'Z'
&SYSLIST(n) &SYSLIST(n,m)	corresponding operand or sublist entry must be a self-defining term	&SYSLIST(3) &SYSLIST(3,2)	24 B'101'
&SYSNDX	none	—	—

Figure 55. Variable Symbols Allowed as Terms in Arithmetic Expression

EVALUATION OF ARITHMETIC EXPRESSIONS: The assembler evaluates arithmetic expressions at preassembly time as follows:

1. It evaluates each arithmetic term.
2. It performs arithmetic operations from left to right. However,
   a. It performs unary operations before binary operations, and
   b. It performs the binary operations of multiplication and division before the binary operations of addition and subtraction.
3. In division, it gives an integer result; any fractional portion is dropped. Division by zero gives a 0 result.

4. In parenthesized arithmetic expressions, the assembler evaluates the innermost expressions first, and then considers them as arithmetic terms in the next outer level of expressions. It continues this process until the outermost expression is evaluated.

5. The computed result, including intermediate values, must lie in the range -2^{31} through $+2^{31}-1$.

SETC VARIABLES IN ARITHMETIC EXPRESSIONS: Assembler H permits a SETC variable to be used as a term in an arithmetic expression if the character string value of the variable is a self-defining term. The value represented by the string is assigned to the arithmetic term. A null string is treated as zero. (The OS/VS Assembler allows SETC variables as arithmetic terms only if the value of the variable is a decimal self-defining term, not longer than 10 characters.)

Examples

Name	Operation	Operand
	LCLC	&C(5)
&C(1)	SETC	'B''101'''
&C(2)	SETC	'C''A'''
&C(3)	SETC	'23'
&A	SETA	&C(1)+&C(2)-&C(3)[1]
&AA	SETA	&C(3)[2]

[1]Allowed only by Assembler H
[2]Allowed by the OS/VS Assembler and Assembler H

In evaluating the arithmetic expression in the fifth statement, the first term (&C(1)) is assigned the binary value 101 (5). To that is added the value represented by the EBCDIC character A (hexadecimal C1, which corresponds to decimal 193). Then the value represented by the third term (&C(3)) is subtracted, and the value of &A becomes 5+193-23=175.

This feature allows you to associate numeric values with EBCDIC or hexadecimal characters to be used in such applications as indexing, code conversion, translation, and sorting.

Assume that &X is a character string with the value ABC.

Name	Operation	Operand
&I	SETC	'C'''.'&X'(1,1).'''''
&VAL	SETA	&TRANS(&I)

The first statement sets &I to C'A'. The second statement extracts the 193rd element of &TRANS (C'A' = X'C1' = 193).

The following code will convert a hexadecimal value in &H into a decimal value in &VAL:

Name	Operation	Operand
&X	SETC	'X''&H'''
&VAL	SETA	&X

An arithmetic expression must not contain two terms in succession; however, any term may be preceded by any number of unary operators. +&A*-&B is a value operand for a SETA instruction. The expression &FIELD+- is invalid because it has no final term.

Using SETA symbols

The arithmetic value assigned to a SETA symbol is substituted for the SETA symbol when it is used in an arithmetic expression. If the SETA symbol is not used in an arithmetic expression, the arithmetic value is converted to an unsigned integer, with leading zeros removed. If the value is 0, it is converted to a single 0.

The following example illustrates this rule:

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&TO,&FROM
		LCLA	&A,&B,&C,&D
1	&A	SETA	10
2	&B	SETA	12
3	&C	SETA	&A-&B
4	&D	SETA	&A+&C
	&NAME	ST	2,SAVEAREA
5		L	2,&FROM&C
6		ST	2,&TO&D
		L	2,SAVEAREA
		MEND	
	HERE	MOVE	FIELDA,FIELDB
	HERE	ST	2,SAVEAREA
		L	2,FIELDB2
		ST	2,FIELDA8
		L	2,SAVEAREA

Statements 1 and 2 assign the arithmetic values +10 and +12, respectively, to the SETA symbols &A and &B. Therefore, statement 3 assigns the SETA symbol &C the arithmetic value -2. When &C is used in statement 5, the arithmetic value -2 is converted to the unsigned integer 2. When &C is used in statement 4, however, the arithmetic value -2 is used. Therefore, &D is assigned the arithmetic value +8. When &D is used in statement 6, the arithmetic value +8 is converted to the unsigned integer 8.

The following example shows how the value assigned to a SETA symbol may be changed in a macro definition.

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&TO,&FROM
		LCLA	&A
1	&A	SETA	5
	&NAME	ST	2,SAVEAREA
2		L	2,&FROM&A
3	&A	SETA	8
4		ST	2,&TO&A
		L	2,SAVEAREA
		MEND	
	HERE	MOVE	FIELDA,FIELDB
	HERE	ST	2,SAVEAREA
		L	2,FIELDB5
		ST	2,FIELDA8
		L	2,SAVEAREA

Statement 1 assigns the arithmetic value +5 to SETA symbol &A. In statement 2, &A is converted to the unsigned integer 5. Statement 3 assigns the arithmetic value +8 to &A. In statement 4, therefore, &A is converted to the unsigned integer 8, instead of 5.

A SETA symbol may be used with a symbolic parameter to refer to an operand in an operand sublist. If a SETA symbol is used for this purpose, it must have been assigned a positive value.

Any expression that may be used in the operand field of a SETA instruction may be used to refer to an operand in an operand sublist. Sublists are described in "Sublists in Operands" on page 185.

The following macro definition may be used to add the last operand in an operand sublist to the first operand in an operand sublist and store the result at the first operand. A sample macro instruction and generated statements follow the macro definition.

	Name	Operation	Operand
		MACRO	
1		ADDX	&NUMBER,&REG
		LCLA	&LAST
2	&LAST	SETA	N'&NUMBER
		L	&REG,&NUMBER(1)
3		A	&REG,&NUMBER(&LAST)
		ST	&REG,&NUMBER(1)
		MEND	
4		ADDX	(A,B,C,D,E),3
		L	3,A
		A	3,E
		ST	3,A

&NUMBER is the first symbolic parameter in th operand field of the prototype statement (statement 1). The corresponding characters (A,B,C,D,E) of the macro instruction (statement 4) are a sublist. Statement 2 assigns to &LAST the arithmetic value +5, which is equal to the number of operands in the sublist. Therefore, in statement 3, &NUMBER(&LAST) is replaced by the fifth operand of the sublist.

SETB—SET BINARY

You use the SETB instruction to assign a binary bit value to a SETB symbol. You can assign the bit values, 0 or 1, to a SETB symbol directly and use it as a switch.

If you specify a logical (boolean) expression in the operand field, the assembler evaluates this expression to determine whether it is true or false, and then assigns the value 1 or 0, respectively, to the SETB symbol. You can use this computed value in condition tests or for substitution.

The format of this instruction is:

Name	Operation	Operand
A variable symbol	SETB	One of three options described below

A global variable symbol in the name field must have been previously declared as a SETB symbol in a GBLB instruction. Local SETB symbols need not be declared in a LCLB instruction. The assembler considers any undeclared variable symbol found in

the name field of a SETB instruction as a local SET symbol. The variable symbol is assigned a type attribute value of N.

The three options that can be specified in the operand field are:

- A binary value (0 or 1)
- A binary value enclosed in parentheses

  Note: An arithmetic value enclosed in parentheses is allowed. This value can be represented by an unsigned, decimal, self-defining term; a SETA symbol; or an attribute reference other than the type attribute reference. If the value is 0, the assembler assigns a value of 0 to the symbol in the name field. If the value is not 0, the assembler assigns a value of 1.

- A logical expression enclosed in parentheses

A logical expression is evaluated to determine if it is true or false; the SETB symbol in the name field is then assigned the binary value 1 or 0, corresponding to true or false, respectively. The assembler assigns the explicitly specified binary value (0 or 1) or the computed logical value (0 or 1) to the SETB symbol in the name field.

Subscripted SETB Symbols

The SETB symbol in the name field can be subscripted, but only if the same SETB symbol has been previously declared in a GBLB or LCLB instruction with an allowable dimension.

The assembler assigns the binary value explicitly specified, or implicit in the logical expression present in the operand field, to the position in the declared array given by the value of the subscript. The subscript expression must not be 0, or have a negative value, or exceed the dimension actually specified in the declaration.

Logical (SETB) Expressions

You can use a logical expression to assign a binary value to a SETB symbol. You can also use a logical expression to represent the condition test in an AIF instruction. This use allows you to code a logical expression whose value (0 or 1) will vary according to the values substituted into the expression and thereby determine whether or not a branch is to be taken.

Figure 56 on page 221 defines a logical expression.

Note: An arithmetic relation is two arithmetic expressions separated by a relational operator. A character relation is two character strings (for example, a character expression and a type attribute reference) separated by a relational operator. The relational operators are:

EQ equal

NE not equal

LE less than or equal

LT less than

GE greater than or equal

GT greater than

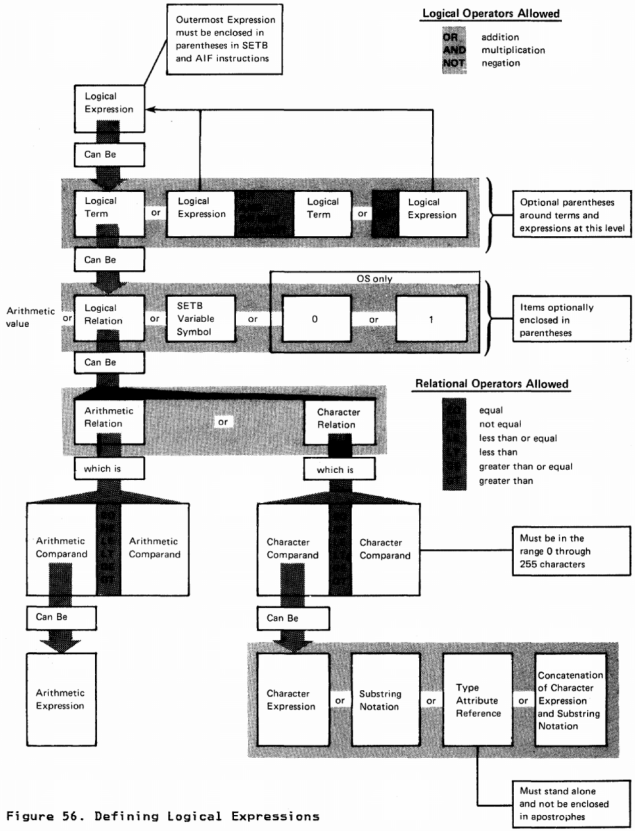


Figure 56. Defining Logical Expressions

RULES FOR CODING LOGICAL EXPRESSIONS: The following is a summary of coding rules for logical expressions:

1. A logical expression must not contain two logical terms in succession.

2. A logical expression can begin with the logical operator NOT.

3. A logical expression can contain two logical operators in succession; however, the only combinations allowed are: OR NOT or AND NOT. The two operators must be separated from each other by one or more blanks.

4. Any logical term, relation, or inner logical expression can be optionally enclosed in parentheses.

5. The relational and logical operators must be immediately preceded and followed by at least one blank or other special character.

6. A logical expression can contain up to 18 logical operators. Note that the relational and other operators used by the arithmetic and character expressions in relations do not count toward this total. There is no limit on the number of parentheses.

EVALUATION OF LOGICAL EXPRESSIONS: The assembler evaluates logical expressions as follows:

1. It evaluates each logical term, which is given a binary value of 0 or 1.

2. If the logical term is an arithmetic or character relation, the assembler evaluates:

   a. The arithmetic or character expressions specified as values for comparison in these relations, and then

   b. The arithmetic or character relation, and finally

   c. The logical term, which is the result of the relation. If the relation is true, the logical term it represents is given a value of 1; if the relation is false, the term is given a value of 0.

   Note: The two comparands in a character relation are compared, character by character, according to binary (EBCDIC) representation of the character. If two comparands in a character relation have character values of unequal length, the assembler always takes the shorter character value to be less than the longer one.

3. The assembler performs logical operations from left to right. However,

   a. It performs logical NOTs before logical ANDs and ORs, and

   b. It performs logical ANDs before logical ORs.

4. In parenthesized logical expressions, the assembler evaluates the innermost expressions first, and then considers them as logical terms in the next outer level of expressions. It continues this process until the outermost expression is evaluated.

USING SETB SYMBOLS: The logical value assigned to a SETB symbol is used for the SETB symbol appearing in the operand field of an AIF instruction or another SETB instruction.

If a SETB symbol is used in the operand field of a SETA instruction, or in arithmetic relations in the operand fields of

AIF and SETB instructions, the binary values 1 (true) and 0 (false) are converted to the arithmetic values +1 and +0, respectively.

If a SETB symbol is used in the operand field of a SETC instruction, in character relations in the operand fields of AIF and SETB instructions, or in any other statement, the binary values 1 (true) and 0 (false), are converted to the character values 1 and 0, respectively.

The following example illustrates these rules. It is assumed that L'&TO EQ 4 is true, and S'&TO EQ 0 is false.

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&TO,&FROM
		LCLA	&A1
		LCLB	&B1,&B2
		LCLC	&C1
1	&B1	SETB	(L'&TO EQ 4)
2	&B2	SETB	(S'&TO EQ 0)
3	&A1	SETA	&B1
4	&C1	SETC	'&B2'
		ST	2,SAVEAREA
		L	2,&FROM&A1
		ST	2,&TO&C1
		L	2,SAVEAREA
		MEND	
	HERE	MOVE	FIELDA,FIELDB
	HERE	ST	2,SAVEAREA
		L	2,FIELDB1
		ST	2,FIELDA0
		L	2,SAVEAREA

Because the operand field of statement 1 is true, &B1 is assigned the binary value 1. Therefore, the arithmetic value +1 is substituted for &B1 in statement 3. Because the operand field of statement 2 is false, &B2 is assigned the binary value 0. Therefore, the character value 0 is substituted for &B2 in statement 4.

SETC—SET CHARACTER

The SETC instruction allows you to assign a character value to a SETC symbol. You can assign whole character strings, or concatenate several smaller strings together. The assembler will assign the composite string to your SETC symbol. You can also assign parts of a character string to a SETC symbol by using the substring notation.

You can change the character value assigned to a SETC symbol. This allows you to use the same SETC symbol with different values for character comparisons in several places, or for substituting different values into the same model statement.

The format of this instruction is:

Name	Operation	Operand
A variable symbol	SETC	One of four options described below

A global variable symbol in the name field must have been previously declared as a SETC symbol in a GBLC instruction. Local SETC symbols need not be declared in a LCLC instruction. The assembler considers any undeclared variable symbol found in

the name field of a SETC instruction as a local SET symbol. The variable symbol is assigned a type attribute value of U.

The four options that can be specified in the operand field are:

- A type attribute reference
- A character expression
- A substring notation
- A concatenation of substring notations, or character expressions, or both

The assembler assigns the character string value represented in the operand field to the SETC symbol in the name field. The string length must be in the range 0 (null character string) through 255 characters.

Note: When a SETA or SETB symbol is specified in a character expression, the unsigned decimal value of the symbol (with leading zeros removed) is the character value given to the symbol.

A duplication factor can precede any of the first three options, or any of the parts (character expression or substring notation) that make up the fourth option of the SETC instruction operand. The duplication factor can be any arithmetic expression allowed in the operand of a SETA instruction. For example:

```
  &C1  SETC  (3)'ABC'
```

assigns the value 'ABCABCABC' to &C1.

Note: The assembler evaluates the character string represented (in particular, the substring) before applying the duplication factor. The resulting character string is then assigned to the SETC symbol in the name field. For example:

```
  &C2  SETC  'ABC'.(3)'ABCDEF'(4,3)
```

assigns the value 'ABCDEFDEFDEF' to &C2.

SUBSCRIPTED SETC SYMBOLS: The SETC symbol (see (1) in Figure 57 on page 225) in the name field can be subscripted, but only if the same SETC symbol has been previously declared (see (2) in Figure 57) in a GBLC or an LCLC instruction with an allowable dimension.

The assembler assigns the character value represented in the operand field to the position in the declared array (see (3) in Figure 57) given by the value of the subscript. The subscript expression must not be 0, or have a negative value, or exceed the dimension (see (4) in Figure 57) actually specified in the declaration.

Character (SETC) Expressions

The main purpose of a character expression is to assign a character value to a SETC symbol. You can then use the SETC symbol to substitute the character string into a model statement.

You can also use a character expression as a value for comparison in condition tests and logical expressions. In addition, a character expression provides the string from which characters can be selected by the substring notation.

Substitution of one or more character values into a character expression allows you to use the character expression wherever you need to vary values for substitution or to control loops.

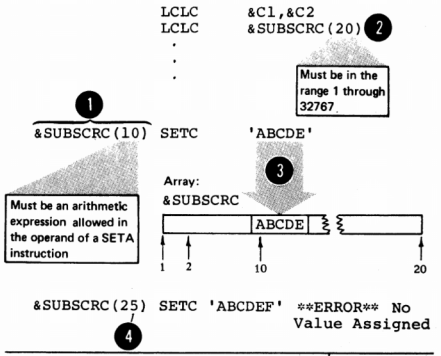


Figure 57. Subscripted SETC Symbols

Character (SETC) expressions can be used only in conditional assembly instructions as shown in Figure 58 on page 226.

A character expression consists of any combination of characters enclosed in single quotation marks. Variable symbols are allowed. The assembler substitutes the representation of their values as character strings into the character expression before evaluating the expression. Up to 255 characters are allowed in a character expression.

Note: Attribute references are not allowed in character expressions.

EVALUATION OF CHARACTER EXPRESSIONS: The value of a character expression is the character string within the enclosing single quotation marks, after the assembler performs any substitution for variable symbols.

Character strings, including variable symbols, can be concatenated to each other within a character expression. The resultant string is the value of the expression used in conditional assembly operations; for example, the value assigned to a SETC symbol.

Notes:

1. Two single quotation marks must be used to generate a single quotation mark as part of the value of a character expression.

   The following statement assigns the character value L'SYMBOL to the SETC symbol &LENGTH.

Can be Used in	Used As	Example
SETC instruction	operand	`&C SETC 'STRING0'`
AIF instruction or SETB instruction	character string in character relation	`AIF ('&C' EQ 'STRING1').B`
Substring notation	first part of notation	`'SELECT'(2,5)=ELECT` (character expression)

Figure 58. Using Character Expressions

Name	Operation	Operand
&LENGTH	SETC	'L''SYMBOL'

2. A double ampersand will generate a double ampersand as part of the value of a character expression. To generate a single ampersand in a character expression, use the substring notation; for example, ('&&'(1,1)).

   The following statement assigns the character value HALF&& to the SETC symbol &AND.

Name	Operation	Operand
&AND	SETC	'HALF&&'

3. To generate a period, two periods must be specified after a variable symbol, or the variable symbol must have a period as part of its value.

   For example, if &ALPHA has been assigned the character value AB%4, the following statement can be used to assign the character value AB%4.RST to the variable symbol &GAMMA.

Name	Operation	Operand
&GAMMA	SETC	'&ALPHA..RST'

CONCATENATION OF CHARACTER STRING VALUES: Character expressions can be concatenated to each other or to substring notations in any order. This concatenated string can then be used in the operand field of a SETC instruction, or as a value for comparison in a logical expression.

The resultant value is a character string composed of the concatenated parts.

Note: The concatenation character (a period) is needed to separate the single quotation mark that ends one character expression from the single quotation mark that begins the next.

For example, either of the following statements may be used to assign the character value ABCDEF to the SETC symbol &BETA.

Name	Operation	Operand
&BETA	SETC	'ABCDEF'
&BETA	SETC	'ABC'.'DEF'

USING SETC SYMBOLS: The character value assigned to a SETC symbol is substituted for the SETC symbol when it is used in the name, operation, or operand field of a statement.

For example, consider the following macro definition, macro instruction, and generated statements.

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&TO,&FROM
		LCLC	&PREFIX
1	&PREFIX	SETC	'FIELD'
	&NAME	ST	2,SAVEAREA
2		L	2,&PREFIX&FROM
3		ST	2,&PREFIX&TO
		L	2,SAVEAREA
		MEND	
	HERE	MOVE	A,B
	HERE	ST	2,SAVEAREA
		L	2,FIELDB
		ST	2,FIELDA
		L	2,SAVEAREA

Statement 1 assigns the character value FIELD to the SETC symbol &PREFIX. In statements 2 and 3, &PREFIX is replaced by FIELD.

The following example shows how the value assigned to a SETC symbol may be changed in a macro definition.

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&TO,&FROM
		LCLC	&PREFIX
1	&PREFIX	SETC	'FIELD'
	&NAME	ST	2,SAVEAREA
2		L	2,&PREFIX&FROM
3	&PREFIX	SETC	'AREA'
4		ST	2,&PREFIX&TO
		L	2,SAVEAREA
		MEND	
	HERE	MOVE	A,B
	HERE	ST	2,SAVEAREA
		L	2,FIELDB
		ST	2,AREAA
		L	2,SAVEAREA

Statement 1 assigns the character value FIELD to the SETC symbol &PREFIX. Therefore, &PREFIX is replaced by FIELD in statement 2. Statement 3 assigns the character value AREA to &PREFIX.

Therefore, &PREFIX is replaced by AREA, instead of FIELD, in statement 4.

The following example illustrates the use of a substring notation as the operand field of a SETC instruction.

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&TO,&FROM
		LCLC	&PREFIX
1	&PREFIX	SETC	'&TO'(1,5)
	&NAME	ST	2,SAVEAREA
2		L	2,&PREFIX&FROM
		ST	2,&TO
		L	2,SAVEAREA
		MEND	
	HERE	MOVE	FIELDA,B
	HERE	ST	2,SAVEAREA
		L	2,FIELDB
		ST	2,FIELDA
		L	2,SAVEAREA

Statement 1 assigns the substring character value FIELD (the first five characters corresponding to symbolic parameter &TO) to the SETC symbol &PREFIX. Therefore, FIELD replaces &PREFIX in statement 2.

Note: It is not possible, by specifying a string of values separated by commas as the operand of a SETC instruction and then using the SETC symbol as an operand in the macro call, to pass a string of values as parameters in a macro instruction. If you attempt to do this, the operand of the SETC instruction will be passed to the macro instruction as one parameter, not as a list of parameters. If the SETC operand is a sublist, it will also be passed to the macro instruction as one parameter.

Concatenating Substring Notations and Character Expressions: Substring notations can be concatenated with character expressions in the operand field of a SETC instruction. If a substring notation follows a character expression, the two can be concatenated by placing a period between the terminating single quotation mark of the character expression and the opening single quotation mark of the substring notation.

For example, if &ALPHA has been assigned the character value AB%4, and &BETA has been assigned the character value ABCDEF, the following statement assigns &GAMMA the character value AB%4BCD.

Name	Operation	Operand
&GAMMA	SETC	'&ALPHA'.'&BETA'(2,3)

If a substring notation precedes a character expression or another substring notation, the two can be concatenated by writing the opening single quotation mark of the second item immediately after the closing parenthesis of the substring notation.

Optionally, you can place a period between the closing parenthesis of a substring notation and the opening single quotation mark of the next item in the operand field.

If &ALPHA has been assigned the character value AB%4, and &ABC has been assigned the character value 5RS, either of the following statements can be used to assign &WORD the character value AB%45RS.

Name	Operation	Operand
&WORD	SETC	'&ALPHA'(1,4)'&ABC'
&WORD	SETC	'&ALPHA'(1,4)'&ABC'(1,3)

If a SETC symbol is used in the operand field of a SETA instruction, the character value assigned to the SETC symbol must be 1 to 8 decimal digits.

If a SETA symbol is used in the operand field of a SETC statement, the arithmetic value is converted to an unsigned integer with leading zeros removed. If the value is 0, it is converted to a single 0.

EXTENDED SET STATEMENTS

In addition to assigning single values to SET symbols, you can assign values to multiple elements in an array of a subscripted SET symbol with one single SETx instruction. Such an instruction is called an extended SET statement.

The format of an extended SETx statement is:

Name	Operation	Operand
A subscripted variable symbol	{SETA| SETB| SETC}	operand1 ,operand2 ,operand3... ,operand*n*

The name field specifies the name of the SET symbol and the position in the array to which the first value in the operand field is to be assigned. The successive operand values are then assigned to the successive positions in the array. If an operand is omitted, the corresponding element of the array is unchanged. Consider the following example:

Name	Operation	Operand
	LCLA	&LIST(50)
&LIST(11)	SETA	5,10,,20,25,30

The first instruction declares &LIST as a subscripted local SETA symbol. The second instruction assigns values to certain elements of the array &LIST. Thus, the instruction does the same as the following sequence:

Name	Operation	Operand
&LIST(11)	SETA	5
&LIST(12)	SETA	10
&LIST(14)	SETA	20
&LIST(15)	SETA	25
&LIST(16)	SETA	30

ALTERNATIVE STATEMENT FORMAT: You can use the alternative statement format for extended SETx statements. The above coding could then be written as follows:

Name	Operation	Operand	Remarks	Continuation Indicator
&LIST(11)	SETA	5, 10,, 20,25,30	THIS IS AN ARRAY SPECIFICATION	X X

SUBSTRING NOTATION

The substring notation allows you to refer to one or more characters within a character string. You can, therefore, either select characters from the string and use them for substitution or testing, or scan through a complete string, inspecting each character. By concatenating substrings with other substrings or character strings, you can rearrange and build your own strings.

The substring notation can be used only in conditional assembly instructions, as shown in Figure 59.

The substring notation must be specified as follows:

```
'CHARACTER STRING'(e1,e2)
```

where the character string is a character expression from which the substring is to be extracted. The first subscript indicates the first character that is to be extracted from the character string. The second subscript indicates the number of characters to be extracted from the character string, starting with the character indicated by the first subscript. Thus, the second subscript specifies the length of the resulting substring.

Can be Used in	Used as	Example	Value Assigned to SETC symbol
SETC instruction operand	operand	`&C1 SETC 'ABC'(1,3)`	ABC
	part of operand	`&C2 SETC '&C1'(1,2).'DEF'`	ABDEF
SETB or AIF instruction operand (logical expression)	Character value in comparand of character relation	`AIF ('&STRING'(1,4) EQ 'AREA').SEQ` `&B SETB ('&STRING'(1,4).'9' EQ 'FULL9')`	

Figure 59. Substring Notations in Conditional Assembly Instructions

Some examples are:

Examples	Value of Variable Symbol	Character Value of Substring
'ABCDE'(1,5)		ABCDE
'ABCDE'(2,3)		BCD
'&C'(3,3)	ABCDE	CDE
'&PARAM'(3,3)	((A+3)*10)	A+3

The character string must be a valid character expression with a length, N, in the range 1 through 255 characters. The length of the resulting substring must be within the range 0 through 255.

The subscripts, e1 and e2, must be arithmetic expressions. The substring notation is replaced by a value that depends on the three elements: N, e1, and e2, as summarized in Figure 60 on page 232.

The numbers in the following list relate to the numbers in Figure 60:

(1) In the usual case, the assembler generates a correct substring of the specified length.

(2) When e1 has a value of 0 or a negative value, the assembler issues an error message.

(3) When the value of e1 exceeds N, the assembler issues a warning message, and a null string is generated.

(4) When e2 has a value of 0, the assembler generates the null character string. Note that, if e2 is negative, the assembler issues an error message.

(5) When e2 indexes past the end of the character expression (that is, e1+e2 is greater than N+1), the assembler issues a warning message and generates a substring that includes only the characters up to the end of the character expression specified.

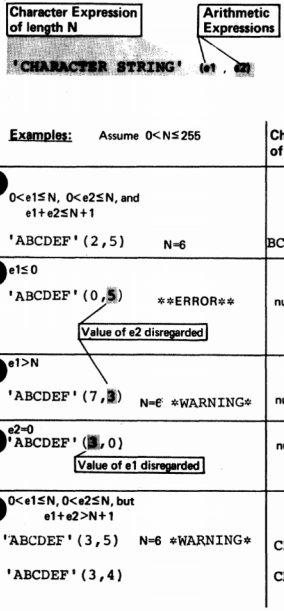


Figure 60. Summary of Substring Notation

BRANCHING

AIF—CONDITIONAL BRANCH

You use the AIF instruction to branch according to the results of a condition test. You can thus alter the sequence in which source program statements or macro definition statements are processed by the assembler.

The AIF instruction also provides loop control for conditional assembly processing, which allows you to control the sequence of statements to be generated.

It also allows you to check for error conditions and thereby to branch to the appropriate MNOTE instruction to issue an error message.

The format of this instruction is:

Name	Operation	Operand
A sequence symbol or blank	AIF	A logical expression enclosed in parentheses, immediately followed by a sequence symbol

The logical expression in the operand field is evaluated at preassembly time to determine if it is true or false. If the expression is true (logical value=1), the statement named by the sequence symbol in the operand field is the next statement processed by the assembler. If the expression is false (logical value=0), the next sequential statement is processed by the assembler.

In the following example, a branch is taken to the label .OUT if &C = YES:

```
          AIF   ('&C' EQ 'YES').OUT
.ERROR    ANOP
          .
          .
          .
.OUT      ANOP
```

The sequence symbol in the operand field is a conditional assembly label that represents an address at preassembly time. It is the address of the statement to which a branch is taken if the logical expression preceding the sequence symbol is true.

The statement identified by the sequence symbol referred to in the AIF instruction can appear before or after the AIF instruction. However, the statement must appear within the local scope of the sequence symbol. Thus, the statement identified by the sequence symbol must appear:

- In open code, if the corresponding AIF instruction does, or
- In the same macro definition in which the corresponding AIF instruction appears.

No branch can be taken from open code into a macro definition or between macro definitions, regardless of nested calls to other macro definitions.

The following macro definition may be used to generate the statements needed to move a fullword fixed-point number from one storage area to another. The statements will be generated only if the type attribute of both storage areas is the letter F.

	Name	Operation	Operand
		MACRO	
	&N	MOVE	&T,&F
1		AIF	(T'&T NE T'&F).END
2		AIF	(T'&T NE 'F').END
3	&N	ST	2,SAVEAREA
		L	2,&F
		ST	2,&T
		L	2,SAVEAREA
4	.END	MEND	

The logical expression in the operand field of statement 1 has the value true if the type attributes of the two macro instruction operands are not equal. If the type attributes are equal, the expression has the logical value false.

Therefore, if the type attributes are not equal, statement 4 (the statement named by the sequence symbol .END) is the next statement processed by the assembler. If the type attributes are equal, statement 2 (the next sequential statement) is processed.

The logical expression in the operand field of statement 2 has the value true if the type attribute of the first macro instruction operand is not the letter F. If the type attribute is the letter F, the expression has the logical value false.

Therefore, if the type attribute is not the letter F, statement 4 (the statement named by the sequence symbol .END) is the next statement processed by the assembler. If the type attribute is the letter F, statement 3 (the next sequential statement) is processed.

Extended AIF Instruction

The extended AIF instruction allows you to combine several successive AIF statements into one statement. The extended AIF instruction has the following format:

Name	Operation	Operand
A sequence symbol or blank	AIF	(logical expression).S1, (logical expression).S2, ..., (logical expression).Sn

The extended AIF instruction is exactly equivalent to n successive AIF statements. The branch is taken to the first sequence symbol (scanning left to right) whose corresponding logical expression is true. If none of the logical expressions is true, no branch is taken.

Consider the following example:

Name	Operation	Operand
	AIF	('&L'(&C,1) EQ '$').DOLR, X ('&L'(&C,1) EQ ' # ').POUND, X ('&L'(&C,1) EQ '@').AT, X ('&L'(&C,1) EQ '=').EQUAL, X ('&L'(&C,1) EQ '(').LEFTPAR, X ('&L'(&C,1) EQ '+').PLUS, X ('&L'(&C,1) EQ '-').MINUS

This statement looks for the occurrence of a $, #, @, =, (, +, and -, in that order; and causes control to branch to .DOLR, .POUND, .AT, .EQUAL, .LEFTPAR, .PLUS, and .MINUS, respectively, if the string being examined contains any of these characters.

ALTERNATIVE STATEMENT FORMAT: The alternative statement format is allowed for extended AIF instructions. The format is illustrated in the above example.

AGO—UNCONDITIONAL BRANCH

The AGO instruction allows you to branch unconditionally. You can thus alter the sequence in which your assembler language statements are processed. This provides you with final exits from conditional assembly loops.

The format of this instruction is:

Name	Operation	Operand
A sequence symbol or blank	AGO	A sequence symbol

The statement named by the sequence symbol in the operand field is the next statement processed by the assembler.

The statement identified by a sequence symbol referred to in the AGO instruction can appear before or after the AGO instruction. However, the statement must appear within the local scope of the sequence symbol. Thus, the statement identified by the sequence symbol must appear

- In open code, if the corresponding AGO instruction does, or
- In the same macro definition in which the corresponding AGO instruction appears.

The following example illustrates the use of the AGO instruction.

	Name	Operation	Operand
		MACRO	
	&NAME	MOVE	&T,&F
1		AIF	(T'&T EQ 'F').FIRST
2		AGO	.END
3	.FIRST	AIF	(T'&T NE T'&F).END
	&NAME	ST	2,SAVEAREA
		L	2,&F
		ST	2,&T
		L	2,SAVEAREA
4	.END	MEND	

Statement 1 is used to determine if the type attribute of the first macro instruction operand is the letter F. If the type attribute is the letter F, statement 3 is the next statement processed by the assembler. If the type attribute is not the letter F, statement 2 is the next statement processed by the assembler.

Statement 2 is used to indicate to the assembler that the next statement to be processed is statement 4 (the statement named by sequence symbol .END).

Computed AGO Instruction

The computed AGO instruction allows you to make branches according to the value of an arithmetic expression specified in the operand. The format of the computed AGO instruction is:

Name	Operation	Operand
A sequence symbol or blank	AGO	(arithmetic expression) .S1,.S2,...,.Sn

If the arithmetic expression evaluates to k, where k lies between 1 and n (inclusive), then the branch is taken to the "k-th" sequence symbol in the list. If k is outside that range, no branch is taken.

In the following example, control passes to the statement at .THIRD if &I=3. Control passes through to the statement following the AGO if &I is less than 1 or greater than 4.

Name	Operation	Operand
	AGO	(&I).FIRST,.SECOND, X .THIRD,.FOURTH

ALTERNATIVE STATEMENT FORMAT: The alternative statement format is allowed for computed AGO instructions. The above example could be coded as follows:

Name	Operation	Operand
	AGO	(&I).FIRST, X .SECOND, X .THIRD, X .FOURTH

ACTR—CONDITIONAL ASSEMBLY LOOP COUNTER

The ACTR instruction allows you to set a conditional assembly loop counter either within a macro definition or in open code. The ACTR instruction can appear anywhere in open code or within a macro definition.

Each time the assembler processes an AIF or AGO branching instruction in a macro definition or in open code, the loop counter for that part of the program is decremented by one. When the number of conditional assembly branches taken reaches the value assigned by the ACTR instruction to the loop counter, the assembler exits from the macro definition or stops processing statements in open code.

By using the ACTR instruction, you avoid excessive looping during conditional assembly processing at preassembly time.

The format of this instruction is as follows:

Name	Operation	Operand
A sequence symbol or blank	ACTR	Any valid arithmetic (SETA) expression

A conditional assembly loop counter is set (or reset) to the value of the arithmetic expression in the operand field. The loop counter has a local scope; its value is decremented only by AGO and AIF instructions, and reassigned only by ACTR

instructions that appear within the same scope. Thus, the nesting of macros has no effect on the setting of individual loop counters.

The assembler sets its own internal loop counter both for open code and for each macro definition, if neither contains an ACTR instruction. The assembler assigns a standard value of 4096 to each of these internal loop counters.

LOOP COUNTER OPERATIONS: Within the local scope of a particular loop counter (including the internal counters run by the assembler), the following occurs:

1. Each time an AGO or AIF branch is executed, the assembler checks the loop counter for zero or a negative value.

2. If the count is not zero or negative, it is decremented by one.

3. If the count is zero, before decrementing, the assembler will take one of two actions:

   a. If it is processing instructions in open code, the assembler will process the remainder of the instructions in the source module as comments. Errors discovered in these instructions during previous passes are flagged.

   b. If it is processing instructions inside a macro definition, the assembler terminates the expansion of that macro definition and processes the next sequential instruction after the calling macro instruction. If the macro definition is called by an inner macro instruction, the assembler processes the next sequential instruction after this inner call; that is, it continues processing at the next outer level of nested macros.

Note: The assembler halves the ACTR counter value when it encounters serious syntax errors in conditional assembly instructions.

ANOP—ASSEMBLY NO OPERATION

You can specify a sequence symbol in the name field of an ANOP instruction, and use the symbol as a label for branching purposes.

The ANOP instruction performs no operation itself, but you can use it to branch to instructions that already have symbols in their name fields. For example, if you wanted to branch to a SETA, SETB, or SETC assignment instruction, which requires a variable symbol in the name field, you could insert a labeled ANOP instruction immediately before the assignment instruction. By branching to the ANOP instruction with an AIF or AGO instruction, you would, in effect, be branching to the assignment instruction.

The format of this instruction is:

Name	Operation	Operand
A sequence symbol or blank	ANOP	Blank

No operation is performed by an ANOP instruction. Instead, if a branch is taken to the ANOP instruction, the assembler processes the next sequential instruction.

The following example illustrates the use of the ANOP instruction.

```
     Name      Operation      Operand
               MACRO
     &NAME     MOVE           &T,&F
               LCLC           &TYPE
1              AIF            (T'&T EQ 'F').FTYPE
2    &TYPE     SETC           'E'
3    .FTYPE    ANOP
4    &NAME     ST&TYPE        2,SAVEAREA
               L&TYPE         2,&F
               ST&TYPE        2,&T
               L&TYPE         2,SAVEAREA
               MEND
```

Statement 1 is used to determine if the type attribute of the first macro instruction operand is the letter F. If the type attribute is not the letter F, statement 2 is the next statement processed by the assembler. If the type attribute is the letter F, statement 4 should be processed next. However, since there is a variable symbol (&NAME) in the name field of statement 4, the required sequence symbol (.FTYPE) cannot be placed in the name field. Therefore, an ANOP instruction (statement 3) must be placed before statement 4.

Then, if the type attribute of the first operand is the letter F, the next statement processed by the assembler is the statement named by sequence symbol .FTYPE. The value of &TYPE retains its initial null character value because the SETC instruction is not processed. Since .FTYPE names an ANOP instruction, the next statement processed by the assembler is statemant 4, the statement following the ANOP instruction.

OPEN CODE

Conditional assembly instructions in open code allow you:

- To select, at preassembly time, statements or groups of statements from the open code portion of a source module according to a predetermined set of conditions. The assembler further processes the selected statements at assembly time.
- To pass local variable information from open code through parameters into macro definitions.
- To control the computation in and generation of macro definitions using global SET symbols.
- To substitute values into the model statements in the open code of a source module and control the sequence of their generation.

All the conditional assembly elements and instructions can be specified in open code.

The specifications for the conditional assembly language described in this chapter also apply in open code. However, the following restrictions apply:

1. To attributes in open code: For ordinary symbols, only references to the type, length, scaling, and integer attributes are allowed.

   Note: References to the number attribute have no meaning in open code, because &SYSLIST is not allowed in open code and symbolic parameters have no meaning in open code.

2. To conditional assembly expressions in open code (see Figure 61 on page 239).

Expression	Must not contain
Arithmetic (SETA)	► &SYSLIST ► Symbolic parameters ► Any attribute references to symbolic parameters, or &SYSLIST,&SYSECT,&SYSNDX
Character (SETC)	► &SYSLIST,&SYSECT,&SYSNDX ► Attribute references to &SYSLIST,&SYSECT, &SYSNDX, or to symbolic parameters ► Symbolic parameters
Logical (SETB)	• Arithmetic expressions with the items listed above • Character expressions with the items listed above

Figure 61. Restrictions on Coding Expressions

MHELP—MACRO TRACE FACILITY

The MHELP instruction controls a set of trace and dump facilities. Options are selected by an absolute expression in the MHELP operand field. MHELP statements can occur anywhere in open code or in macro definitions. MHELP options remain in effect until superseded by another MHELP statement. The format of this instruction is:

Name	Operation	Operand
A sequence symbol or blank	MHELP	Absolute expression, binary or decimal options (see below)

Macro Call Trace—Operand=1

This option provides a one-line trace listing for each macro call, giving the name of the called macro, its nested depth, and its &SYSNDX value. The trace is provided only upon entry into the macro. No trace is provided if error conditions prevent entry into the macro.

Macro Branch Trace—Operand=2

This option provides a one-line trace-listing for each AGO and AIF conditional assembly branch within a macro. It gives the model statement numbers of the "branched from" and the "branched to" statements, and the name of the macro in which the branch occurs. This trace option is suppressed for library macros.

Macro AIF Dump—Operand=4

This option dumps undimensioned SET symbol values from the macro dictionary immediately before each AIF statement that is encountered.

Macro Exit Dump—Operand=8

This option dumps undimensioned SET symbols from the macro dictionary whenever an MEND or MEXIT statement is encountered.

Macro Entry Dump—Operand=16

This option dumps parameter values from the macro dictionary immediately after a macro call is processed.

Global Suppression—Operand=32

This option suppresses global SET symbols in two preceding options, MHELP 4 and MHELP 8.

MHELP Suppression—Operand=128

This option suppresses all currently active MHELP options.

MHELP Control on &SYSNDX

The MHELP operand field is actually mapped into a fullword. Previously defined MHELP codes correspond to the fourth byte of this fullword.

&SYSNDX control is turned on by any bit in the third byte (operand values 256 through 65535, inclusive). Then, when &SYSNDX (total number of macro calls) exceeds the value of the fullword which contains the MHELP operand value, control is forced to stay at the open code level by, in effect, making every statement in a macro behave like a MEXIT. Open code macro calls are honored, but with an immediate exit back to open code.

Some examples are:

```
MHELP 256      Limit &SYSNDX to 256.
MHELP 1        Trace macro calls.
MHELP 256+1    Trace calls and limit &SYSNDX to 257.
MHELP 65536    No effect. No bits in bytes 3,4.
MHELP 65792    Limit &SYSNDX to 65792.
```

When the value of &SYSNDX reaches its limit, the message 'ACTR EXCEEDED—&SYSNDX' is issued.

Combining Options

As shown in the example above, multiple options can be obtained by combining the option codes in one MHELP operand. For example, call and branch traces can be invoked by MHELP B'11', MHELP 2+1, or MHELP 3. Substitution by means of variable symbols may also be used.

Appendix A shows the basic machine formats in relation to the format of the assembler operand field and applicable instructions.

Appendix B lists the related operation, name, and operand entries.

Appendix C lists the constant types and gives related information concerning each.

Appendix D summarizes the macro language described in Part 2 of this publication.

APPENDIX A. MACHINE INSTRUCTION FORMAT

Figure 62 on page 243 is a summary of machine instruction formats.

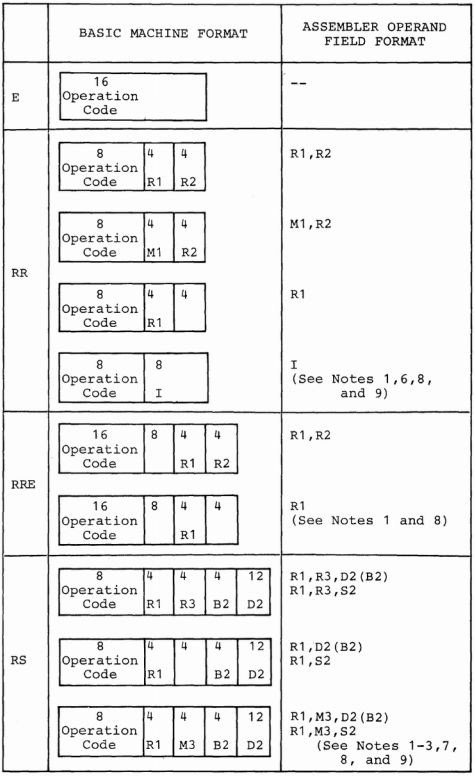


Figure 62 (Part 1 of 2). Machine Instruction Format

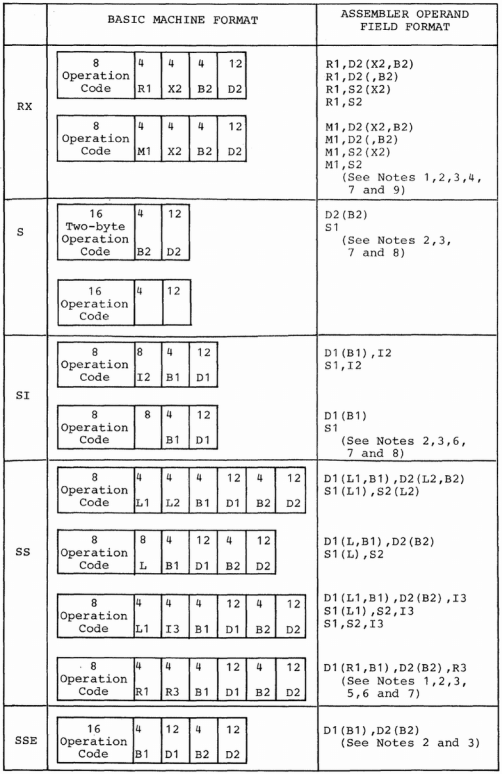


Figure 62 (Part 2 of 2). Machine Instruction Format

Notes to Figure 62:

1. R1, R2, and R3 are absolute expressions that specify general or floating-point registers. The general register numbers are 0 through 15; floating-point register numbers are 0, 2, 4, and 6.

2. D1 and D2 are absolute expressions that specify displacements. A value of 0 through 4095 may be specified.

3. B1 and B2 are absolute expressions that specify base registers. Register numbers are 0 through 15.

4. X2 is an absolute expression that specifies an index register. Register numbers are 0 through 15.

5. L, L1, and L2 are absolute expressions that specify field lengths. An L expression can specify a value of 1 through 256. L1 and L2 expressions can specify a value of 1 through 16. In all cases, the assembled value will be one less than the specified value.

6. I, I2, and I3 are absolute expressions that provide immediate data. The value of I and I2 may be 0 through 255. The value of I3 may be 0 through 9.

7. S1 and S2 are absolute or relocatable expressions that specify an address.

8. RR, RRE, RS, S, and SI instruction fields that are blank under Basic Machine Format are not examined during instruction execution. The fields are not written in the symbolic operand, but are assembled as binary zeros.

9. M1 and M3 specify a 4-bit mask.

Figure 63 summarizes assembler instructions, and Figure 64 on page 249 summarizes assembler statements.

Operation Entry	Name Entry	Operand Entry
ACTR	A sequence symbol or not present	An arithmetic SETA expression
AGO	A sequence symbol or not present	A sequence symbol
AIF	A sequence symbol or not present	A logical expression enclosed in parentheses, immediately followed by a sequence symbol
AMODE	A sequence symbol or blank	24, 31, or ANY
ANOP	A sequence symbol or not present	Will be taken as a remark
AREAD	Any SETC symbol	One ordinary symbol
CCW	Any symbol or not present	Four operands, separated by commas
CCW0	Any symbol or not present	Four operands, separated by commas
CCW1	Any symbol or not present	Four operands, separated by commas
CNOP	Any symbol or not present	Two absolute expressions, separated by a comma
COM	A sequence symbol or not present	Will be taken as a remark
COPY	Must not be present	A symbol
CSECT	Any symbol or not present	Will be taken as a remark
DC	Any symbol or not present	One or more operands, separated by commas
DROP	A sequence symbol or not present	One to 16 absolute expressions, separated by commas
DS	Any symbol or not present	One or more operands, separated by commas
DSECT	A variable symbol or an ordinary symbol	Will be taken as a remark
EJECT	A sequence symbol or not present	Will be taken as a remark
END	A sequence symbol or not present	A relocatable expression or not present
ENTRY	A sequence symbol or not present	One or more relocatable symbols, separated by commas
EQU	A variable symbol or an ordinary symbol	An absolute or relocatable expression

Figure 63 (Part 1 of 3). Assembler Instructions

Operation Entry	Name Entry	Operand Entry
EXTRN	A sequence symbol or not present	One or more relocatable symbols, separated by commas
GBLA	Must not be present	One or more variable symbols that are to be used as SET symbols, separated by commas[1]
GBLB	Must not be present	One or more variable symbols that are to be used as SET symbols, separated by commas[1]
GBLC	Must not be present	One or more variable symbols that are to be used as SET symbols, separated by commas[1]
ICTL	Must not be present	One to three decimal values, separated by commas
ISEQ	Must not be present	Two decimal values, separated by a comma
LCLA	Must not be present	One or more variable symbols that are to be used as SET symbols, separated by commas[1]
LCLB	Must not be present	One or more variable symbols that are to be used as SET symbols, separated by commas[1]
LCLC	Must not be present	One or more variable symbols separated by commas[1]
LOCTR	A variable or ordinary symbol	Blank
LTORG	Any symbol or not present	Will be taken as a remark
MACRO[2]	Must not be present	Will be taken as a remark
MEND[2]	A sequence symbol or not present	Will be taken as a remark
MEXIT[2]	A sequence symbol or not present	Will be taken as a remark
MNOTE[2]	A sequence symbol, a variable symbol, or not present	A severity code, followed by a comma, followed by any combination of characters enclosed in single quotation marks
ORG	A sequence symbol or not present	A relocatable expression or not present
PRINT	A sequence symbol or not present	One to three operands
PUNCH	A sequence symbol or not present	One to 80 characters enclosed in single quotation marks
REPRO	A sequence symbol or not present	Will be taken as a remark
RMODE	Any symbol or blank	24 or ANY
SETA	A SETA symbol	An arithmetic expression
SETB	A SETB symbol	A 0 or a 1, or logical expression enclosed in parentheses

Figure 63 (Part 2 of 3). Assembler Instructions

Operation Entry	Name Entry	Operand Entry
SETC	A SETC symbol	A type attribute, a character expression, a substring notation, or a concatenation of character expressions and substring notations
SPACE	A sequence symbol or not present	A decimal self-defining term or not present
START	Any symbol or not present	A self-defining term or not present
TITLE[3]	A special symbol (0 to 4 characters), a sequence symbol, a variable symbol, or not present	One to 100 characters, enclosed in single quotation marks
USING	A sequence symbol or not present	An absolute or relocatable expression followed by 1 to 16 absolute expressions, separated by commas
WXTRN	A sequence symbol or not present	One or more relocatable symbols, separated by commas

Figure 63 (Part 3 of 3). Assembler Instructions

Notes to Figure 63:

[1] SET symbols may be defined as subscripted SET symbols.

[2] May only be used as part of a macro definition.

[3] See "Chapter 5. Assembler Instruction Statements" on page 85 for a description of the name entry.

Instruction Entry	Name Entry	Operand Entry
Model Statements[1] [2]	An ordinary symbol, variable symbol, sequence variable symbol, a combination of variable symbols and other characters that is equivalent to a symbol, or not present	Any combination of characters (including variable symbols)
Prototype Statement[3]	A symbolic parameter or not present	Zero or more operands that are symbolic parameters (separated by commas) followed by zero or more operands (separated by commas) of the form symbolic parameter, equal sign, optional standard value
Macro Instruction Statement[3]	An ordinary symbol, a variable symbol, a sequence symbol, a combination of variable symbols and other characters that is equivalent to a symbol,[4] or not present	Zero or more positional operands (separated by commas) followed by zero or more keyword operands (separated by commas) of the form keyword, equal sign, value[5]
Assembler Language Statement[1] [2]	An ordinary symbol, a variable symbol, a sequence symbol, a combination of variable symbols and other characters that is equivalent to a symbol, or not present	Any combination of characters (including variable symbols)

Figure 64. Assembler Statements

Notes to Figure 64:

1. Variable symbols may be used to generate assembler language mnemonic operation codes (listed in "Chapter 5. Assembler Instruction Statements" on page 85), except ACTR, COPY, END, ICTL, CSECT, DSECT, ISEQ, PRINT, REPRO, and START. Variable symbols may not be used in the name and operand entries of: COPY, END, ICTL, or ISEQ.
2. No substitution is performed for variables in the line following a REPRO statement.
3. May only be used as part of a macro definition.
4. When the name field of a macro instruction contains a sequence symbol, the sequence symbol is not passed as a name field parameter. It only has meaning as a possible branch target for conditional assembly.
5. Variable symbols appearing in a macro instruction are replaced by their values before the macro instruction is processed.

APPENDIX C. SUMMARY OF CONSTANTS

Figure 65 is a summary of assembler constants.

TYPE	IMPLICIT LENGTH (BYTES)	ALIGN-MENT	LENGTH MODI-FIER RANGE	SPECIFIED BY	NUMBER OF CON-STANTS PER OPERAND	RANGE FOR EX-PONENTS	RANGE FOR SCALE	TRUN-CATION/ PADDING SIDE
C	as needed	byte	.1 to 256 (1)	characters	one			right
X	as needed	byte	.1 to 256 (1)	hexadecimal digits	multi-ple			left
B	as needed	byte	.1 to 256	binary digits	multi-ple			left
F	4	word	.1 to 8	decimal digits	multi-ple	-85 to +75	-187 to +346	left (3)
H	2	half-word	.1 to 8	decimal digits	multi-ple	-85 to +75	-187 +346	left (3)
E	4	word	.1 to 8	decimal digits	multi-ple	-85 to +75	0-14	right (3)
D	8	double-word	.1 to 8	decimal digits	multi-ple	-85 to +75	0-14	right (3)
L	16	double-word	.1 to 16	decimal digits	multi-ple	-85 to +75	0-28	right (3)
P	as needed	byte	.1 to 16	decimal digits	multi-ple			left
Z	as needed	byte	.1 to 16	decimal digits	multi-ple			left
A	4	word	.1 to 4 (2)	any expression	multi-ple			left
Q	4	word	1-4	symbol naming a DXD or DSECT	multi-ple			left
V	4	word	3,4	relocatable symbol	multi-ple			left
S	2	half-word	2 only	one absolute or relocatable expression or two absolute expressions: exp-(exp)	multi-ple			
Y	2	half-word	.1 to 2 (2)	any expression	multi-ple			left

(1) In a DS assembler instruction C and X type constants can have length specification to 65535.
(2) Bit length specification permitted with absolute expressions only. Relocatable A-type constants, 3 or 4 bytes only; relocatable Y-type constants, 2 bytes only.
(3) Errors will be flagged if significant bits are truncated or if the value specified cannot be contained in the implicit length of the constant.

Figure 65. Summary of Constants

APPENDIX D. MACRO LANGUAGE SUMMARY

This appendix summarizes the macro language described in Part 2 of this publication. Figure 66 on page 252 indicates which macro language elements may be used in the name and operand entries of each statement. Figure 67 on page 253 is a summary of the expressions that may be used in macro instruction statements. Figure 68 on page 255 is a summary of the attributes that may be used in each expression. Figure 69 on page 257 is a summary of the variable symbols that may be used in each expression.

Figure 66. Macro Language Elements

	Variable Symbols													Attributes						
		Global SET Symbols			Local SET Symbols			System Variable Symbols												
Statement	Symbolic Parameter	SETA	SETB	SETC	SETA	SETB	SETC	&SYSNDX	&SYSECT	&SYSLIST	&SYSPARM	&SYSDATE	&SYSTIME	Type	Length	Scaling	Integer	Count	Number	Sequence Symbol
MACRO																				
Prototype Statement	Name Operand																			
GBLA		Operand																		
GBLB			Operand																	
GBLC				Operand																
LCLA					Operand															
LCLB						Operand														
LCLC							Operand													
Model Statement	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Operand	Operand							Name
SETA	Operand[2]	Name Operand	Operand[3]	Operand[9]	Name Operand	Operand[3]	Operand[9]	Operand		Operand[2]	Operand[9]				Operand	Operand	Operand	Operand	Operand	
SETB	Operand[6]	Operand[6]	Name Operand	Operand[6]	Operand[6]	Name Operand	Operand[6]	Operand[6]	Operand[4]	Operand[6]	Operand[6]			Operand[4]	Operand[5]	Operand[5]	Operand[5]	Operand[5]	Operand[5]	
SETC	Operand	Operand[7]	Operand[8]	Name Operand	Operand[7]	Operand[8]	Name Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand						
AIF	Operand[6]	Operand[6]	Operand	Operand[6]	Operand[6]	Operand	Operand[6]	Operand[6]	Operand[4]	Operand[6]	Operand[6]			Operand[4]	Operand[5]	Operand[5]	Operand[5]	Operand[5]	Operand[5]	Name Operand
AGO																				Name Operand
ACTR	Operand[2]	Operand	Operand[3]	Operand[2]	Operand	Operand[3]	Operand[2]	Operand		Operand[2]	Operand[2]				Operand	Operand	Operand	Operand	Operand	
ANOP																				Name
AREAD					Name			Name												
MEXIT																				Name
MNOTE	Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand	Operand							Name
MEND																				Name
Outer Macro		Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand				Name Operand	Operand	Operand							Name
Inner Macro	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Name Operand	Operand	Operand							Name
Assembler Language Statement		Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand	Name Operation Operand													Name

1. Variable symbols in macro-instructions are replaced by their values before processing.
2. Only if value is self-defining term.
3. Converted to arithmetic +1 or +0.
4. Only in character relations.
5. Only in arithmetic relations.
6. Only in arithmetic or character relations.
7. Converted to unsigned number.
8. Converted to character 1 or 0.
9. Only if one to ten decimal digits

Expression	Arithmetic Expressions	Character Expressions	Logical Expressions
Can contain	Self-defining terms	Any combination of characters enclosed in apostrophes	A 0 or a 1
	Length, scaling, integer, count, and number attributes	Any variable symbol enclosed in apostrophes	SETB symbols
	SETA and SETB symbols[1]	A concatenation of variable symbols and other characters enclosed in apostrophes	Arithmetic relations[1]
	SETC symbols whose values are a decimal self-defining term[1]	A type attribute reference	Character relations[2]
	&SYSPARM if its value is a decimal self-defining term		Arithmetic value
	Symbolic parameters if the corresponding operand is a decimal self-defining term		
	&SYSLIST (n) if the corresponding operand is a decimal self-defining term		
	&SYSLIST (n,m) if the corresponding operand is a decimal self- defining term		
	&SYSNDX		
Operations are	+, - (unary and binary), *, and /; parentheses permitted	Concatenation, with a period (.)	AND, OR, and NOT parentheses permitted
Range of values	-2^{31} to $+2^{31}-1$	0 through 255 characters	0 (false) or 1 (true)
May be used in	SETA operands	SETC operands	SETB operands
	Arithmetic relations	Character relations[2]	AIF operands
	Subscripted SET symbols		
	&SYSLIST subscript(s)		
	Substring notation		
	Sublist notation		

Figure 67. Conditional Assembly Expressions

Notes to Figure 67 on page 253:

1 Values must be from 0 through 2 147 483 647.

2 A character relation consists of two character expressions related by the operator GT, LT, EQ, NE, GE, or LE. Type attribute notation and substring notation may also be used in character relations. The maximum size of the character expressions that can be compared is 255 characters. If the two character expressions are of unequal size, the smaller one will always compare less than the larger.

Attribute	Notation	Can be used with:	Can be used only if type attribute is:	Can be used in
Type	T'	Ordinary Symbols defined in open code; symbolic parameters inside macro definitions; &SYSLIST (m), &SYSLIST (m,n), SET symbols; &SYSTIME, &SYSPARM, &SYSDATE, &SYSECT, &SYSNDX, &SYSLOC	(May always be used)	1. SETC operand fields 2. Character relations
Length	L'	Ordinary Symbols defined in open code; symbolic parameters inside macro definitions; &SYSLIST (m), and &SYSLIST (m,n) inside macro definitions	Any letter except M,N,O,T and U	Arithmetic expressions
Scaling	S'	Ordinary Symbols defined in open code; symbolic parameters inside macro definitions; &SYSLIST (m), and &SYSLIST (m,n) inside macro definitions	H,F,G,D,E,L,K,P, and Z	Arithmetic expressions
Integer	I'	Ordinary Symbols defined in open code; symbolic parameters inside macro definitions; &SYSLIST (m), and &SYSLIST (m,n) inside macro definitions	H,F,G,D,E,L,K,P, and Z	Arithmetic expressions
Count	K'	Symbolic parameters, &SYSLIST (m) and &SYSLIST (m,n) inside macro definitions SET symbols; all system variable symbols	Any letter	Arithmetic expressions
Number	N'	Symbolic parameters, &SYSLIST and &SYSLIST (m) inside macro definitions	Any letter	Arithmetic expressions

Figure 68 (Part 1 of 2). Attributes

Attribute	Nota-tion	Can be used with:	Can be used only if type attribute is:	Can be used in
Defined	D'	Ordinary Symbols defined in open code; symbolic parameters inside macro definitions; &SYSLIST (m), and &SYSLIST (m,n) inside macro definitions	H,F,G,D,E,L,K,P, and Z	Arithmetic expressions

Figure 68 (Part 2 of 2). Attributes

Note: There are definite restrictions on the use of these attributes. Refer to "Chapter 9. How to Write Conditional Assembly Instructions" on page 195.

Variable Symbol	Declared by:	Initialized, or set to:	Value changed by:	May be used in:
Symbolic[1] paramater	Prototype statement	Corresponding macro instruction operand	Constant throughout definition	Arithmetic expressions if operand is decimal self-defining term Character expressions
SETA	LCLA or GBLA instruction	0	SETA instruction	Arithmetic expressions Character expressions
SETB	LCLB or GBLB instruction	0	SETB instruction	Arithmetic expressions Character expressions Logical expressions
SETC	LCLC or GBLC instruction	String of length 0 (null)	SETC instruction	Arithmetic expressions if value is decimal self-defining term Character expressions
&SYSNDX[1]	The assembler	Macro instruction index	Constant throughout definition; unique for each macro instruction	Arithmetic expressions Character expressions
&SYSECT[1]	The assembler	Control section in which macro instruction appears	Constant throughout definition; set by CSECT, DSECT, START, and COM	Character expressions
&SYSLIST[1]	The assembler	Not applicable	Not applicable	N'&SYSLIST in arithmetic expressions
&SYSLIST (n) [1] &SYSLIST (n,m) [1]	The assembler	Corresponding macro instruction operand	Constant throughout definition	Arithmetic expressions if operand is decimal self-defining term
				Character expressions

Figure 69 (Part 1 of 2). Variable Symbols

Variable Symbol	Declared by:	Initialized, or set to:	Value changed by:	May be used in:
&SYSPARM	PARM field	User defined or null	Constant throughout assembly	Arithmetic expression if value is decimal self-defining term Character expression
&SYSTIME	The assembler	System time	Constant throughout assembly	Character expression
&SYSDATE	The assembler	System date	Constant throughout assembly	Character expression
&SYSLOC[1]	The assembler	Location counter in effect where macro instruction appears	Constant throughout definition; set by CSECT, DSECT, START, COM, and LOCTR	Character expression

Figure 69 (Part 2 of 2). Variable Symbols

Note to Figure 69 on page 257:

[1] Can be used only in macro definitions.

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